PY G345/4.10/7
no. 88

Information Circular 88
1980

Coal Resources of Pennsylvania

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

Digitized by the Internet Archive
in 2016 with funding from
This project is made possible by a grant from the Institute of Museum and Library Services as administered by the Pennsylvania Department of Education through the Office of Commonwealth Libraries

https://archive.org/details/coalresourcesofp00soco_0

Information Circular 88

COAL RESOURCES OF PENNSYLVANIA

Authors:

Arthur A. Socolow, Director and State Geologist
Thomas M. Berg, Chief, Geologic Mapping Division
Albert D. Glover, Head, Coal Geology Section
Clifford H. Dodge, Coal Geologist
Henry W. Schasse, Coal Geologist
James R. Shaulis, Coal Geologist
Viktoras W. Skema, Coal Geologist
Sandra Blust, Librarian

PENNSYLVANIA GEOLOGICAL SURVEY

FOURTH SERIES

HARRISBURG

1980

Copyright 1980
by the
Commonwealth of Pennsylvania
Quotations from this book may be published if credit is given to
the Pennsylvania Geological Survey

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PURCHASED FROM
STATE BOOK STORE, P.O. BOX 1365
HARRISBURG, PENNSYLVANIA 17125

PREFACE

An important goal of the Bureau of Topographic and Geologic Survey within the Department of Environmental Resources is to provide Pennsylvanians with accurate information on coal. Bituminous and anthracite coal resources within the Commonwealth will continue to be a critically important asset as the nation moves to meet the energy needs of the present and future. Development of these very large coal resources will require careful planning which, in turn, will require an accurate and detailed data base. Because knowledge is necessary to the planning process, the Bureau has responded and will continue to respond by searching for and accumulating coal information, and by developing coal exploration methods.

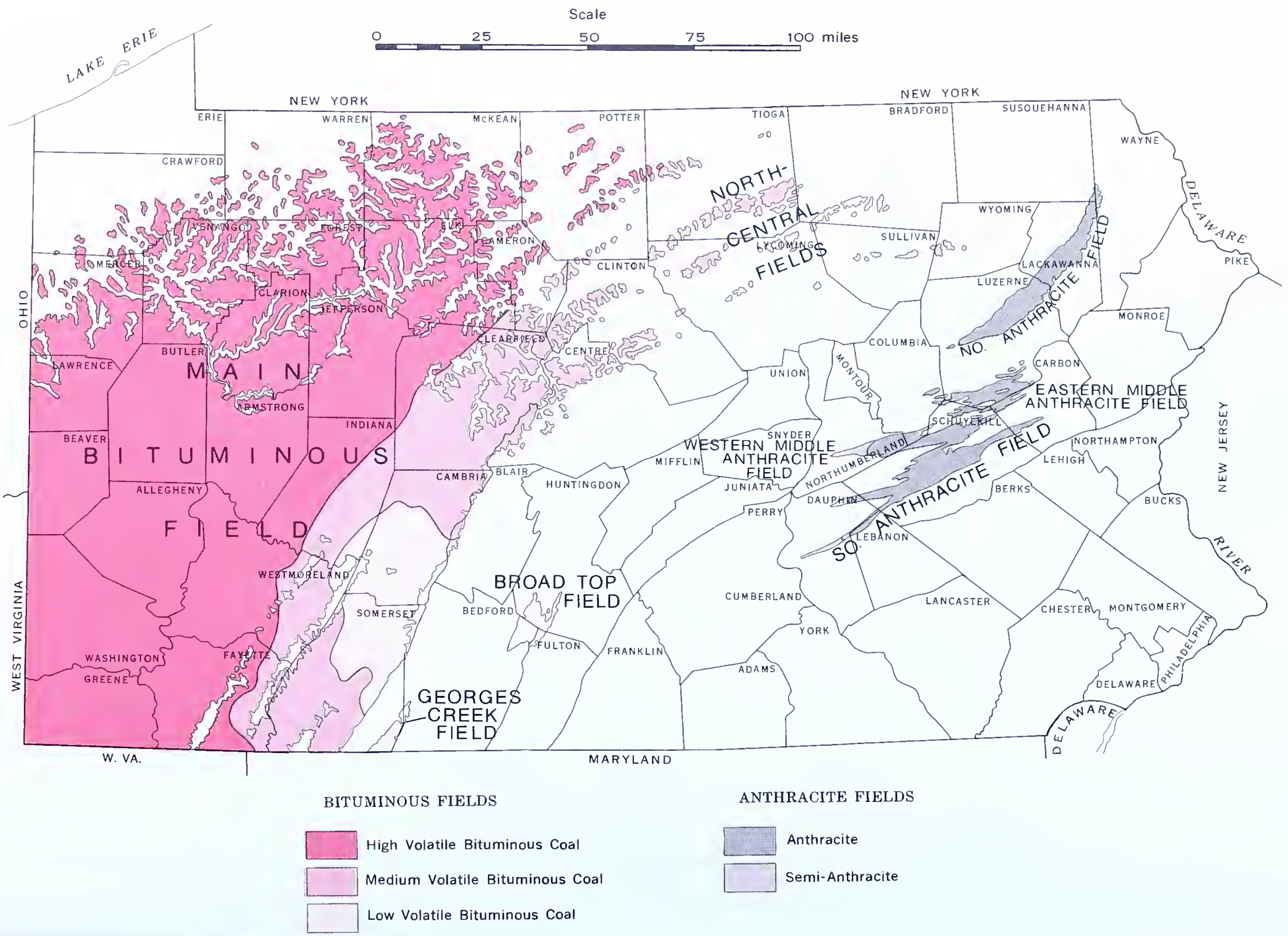
At the request of Governor Dick Thornburgh, the Bureau prepared a booklet for the *Governor's Coal Conference* of January 23-24, 1980, summarizing the coal resources of Pennsylvania and indicating their location, quantity, and quality. The booklet contained a series of summary maps and tables, and a list of references. The materials contained in the booklet were intended to form a sound geologic base for discussions and planning sessions that centered on the myriad problems of coal exploration and development. Because of popular demand, the *Coal Conference* booklet is issued here as a Survey Information Circular. It is hoped that this circular will serve a wide audience and that it will spur development and wise use of one of Pennsylvania's most important natural resources.

CONTENTS

Page

Preface iii
Map showing distribution of Pennsylvania coals vi
We have the coal 1
    Summary of coal reserves of Pennsylvania. 1
    Recoverable coal reserves in beds over 28 inches thick 2
    Estimated strippable coal reserves of sixteen southwestern Pennsylvania counties. 3
Our coal investigations: past, present, and future 4
Stratigraphic position of Pennsylvania's major bituminous coal seams 6
Distribution and thickness of the Pittsburgh coal 8
Distribution and thickness of the Upper Freeport coal 10
Distribution and thickness of the Lower Kittanning coal 12
Sulfur content of anthracite coals 14
Sulfur content of the Pittsburgh coal 16
Sulfur content of coals above the Pittsburgh seam 18
Sulfur content of coals in the upper part of the Allegheny Group. 20
Sulfur content of coals in the lower part of the Allegheny Group. 22
Distribution of fixed carbon in Pennsylvania coals 24
Distribution of volatiles in Pennsylvania coals. 26
Heat values of Pennsylvania coals 28
Bibliography 30

DISTRIBUTION OF PENNSYLVANIA COALS



WE HAVE THE COAL

Development of coal reserves involves many factors, but first and foremost there must be an adequate quantity of coal reserves to make any effort towards increased coal development worthwhile.

PENNSYLVANIA HAS A LARGE AND ADEQUATE SUPPLY OF AVAILABLE COAL RESERVES!

Pennsylvania was blessed with a total of 103 billion tons of coal in the ground. Even though coal mining has been going on here since at least 1759, only 23 billion tons has been mined out (or lost due to mining).

Eighty billion tons of coal still remains in the ground under Pennsylvania today! Some of this coal, however, is too thin to mine; some is too deep to mine; some has to be left in the ground (for pillars, etc.) when mining does take place. Taking these factors into account with today's technology, *Pennsylvania still has 30 billion tons of recoverable coal.*

Pennsylvania's remaining 30 billion tons of recoverable coal is more than has been mined out and lost in the past 220 years!

Pennsylvania's remaining 30 billion tons of recoverable coal would last us for 350 years at the present annual rate of coal production (85 million tons a year)!

Pennsylvania's remaining 30 billion tons of recoverable coal would last us for over 150 years, even if we double the present annual rate of production!

SUMMARY OF COAL RESERVES OF PENNSYLVANIA

Remaining Coal in the Ground:	
Bituminous	64 billion tons
Anthracite	16 billion tons
TOTAL REMAINING COAL	80 billion tons
Recoverable Coal:	
Bituminous (over 28″ thick)	22 billion tons
Anthracite (over 24″ thick)	8 billion tons
TOTAL RECOVERABLE COAL	30 BILLION TONS

RECOVERABLE COAL RESERVES IN BEDS OVER 28 INCHES THICK

MAIN BITUMINOUS AND GEORGES CREEK FIELDS

Allegheny County	680	million tons
Armstrong	1,100	
Beaver	350	
Blair	9	
Butler	860	
Cambria	1,000	
Cameron	13	
Centre	83	
Clarion	450	
Clearfield	710	
Clinton	9	
Elk	110	
Fayette	2,100	
Greene	4,000	
Indiana	1,700	
Jefferson	880	
Lawrence	150	
McKean	96	
Mercer	82	
Somerset	1,600	
Venango	81	
Washington	3,800	
Westmoreland	1,900	
Subtotal		21,763 million tons

BROAD TOP FIELD

Bedford	66	
Fulton	8	
Huntingdon	18	
Subtotal		92 million tons

NORTH-CENTRAL FIELDS

Bradford	4	
Lycoming	17	
Sullivan	3	
Tioga	13	
Subtotal		37 million tons

RECOVERABLE COAL RESERVES IN BEDS OVER 28 INCHES THICK

(Continued)

ANTHRACITE FIELDS

Carbon	135	
Columbia	216	
Dauphin	330	
Lackawanna	153	
Lebanon	450	
Luzerne	738	
Northumberland	846	
Schuylkill	4,410	
Susquehanna	2	
Wayne	3	
	Subtotal	7,283 million tons
PENNSYLVANIA TOTAL		29,175 million tons

ESTIMATED STRIPPABLE COAL RESERVES OF SIXTEEN SOUTHWESTERN PENNSYLVANIA COUNTIES

COUNTY	REMAINING COAL IN PLACE WITH 0-120 FEET OF OVERBURDEN LESS 20% MINING LOSS
Allegheny	32.0 million tons
Armstrong	144.5
Beaver	62.7
Butler	233.1
Cambria	59.3
Clarion	137.1
Clearfield	170.4
Fayette	81.9
Greene	49.4
Indiana	57.2
Jefferson	84.1
Lawrence	29.6
Mercer	71.3
Somerset	105.4
Washington	148.2
Westmoreland	32.2
TOTAL	1498.4 million tons

OUR COAL INVESTIGATIONS: PAST, PRESENT, AND FUTURE

Pennsylvania coal. The reserves are tremendous. We have long felt that, as the nation moves toward the twenty-first century, this natural resource can serve as fuel and raw material for the greatest leaps of mankind. Now that we face unexpected shortages of oil, and grave doubts over the use of nuclear power, our coal lies ready to serve our needs.

Exactly where is it, how much is left, and what are its characteristics? *Location*, *Quantity*, and *Quality:* these basic aspects of Pennsylvania coal must continue to be investigated, described, and documented as plans are laid for the future. Knowledge is necessary to the planning process.

Determining the location, quantity, and quality of coal in this state has been one of the biggest and most important tasks of the Pennsylvania Geological Survey since its beginning in 1836. Although the work of the Survey has dealt with many geologic subjects other than coal, the list of Survey publications focusing on coal is extensive.

The mapping and analysis of coal deposits went hand-in-hand with America's growing reliance upon coal as the source of nearly all energy. The coal fields were initially outlined by the Pennsylvania Survey's first Director, Henry D. Rogers, in the 1840's and 1850's. However, detail as needed today was lacking. Detailed mapping of Pennsylvania anthracite during the late 1800's was carried out under the direction of Survey Geologist Charles A. Ashburner; much of his work still stands today as a primary source of information. Mapping of strata containing bituminous coal in western Pennsylvania was done under J. P. Lesley in connection with the county-by-county mapping of Pennsylvania during the late 1800's, but the available base maps were inaccurate, and concepts of coal occurrence were unrealistically simple. Mapping of the coal measures of Pennsylvania has continued in the twentieth century right up to the present time, in recognition of the existing and future importance of our coal resources. The U. S. Geological Survey provided a major contribution in the early part of this century when its geologists compiled comprehensive geologic "folios" for 19 areas in western Pennsylvania. That work was continued by the Pennsylvania Geological Survey in its Atlas Series under the direction of George H. Ashley. Since 1925, seventeen Atlas reports have been published for quadrangles in western Pennsylvania, containing great detail on the coal resources of the areas mapped. Additional detailed mapping of anthracite-bearing strata in the Southern and Western Middle Anthracite fields was carried out by the U. S. Geological Survey and published during the 1960's and 1970's as part of its "Geologic Quadrangle" series. Such maps have also been completed for about a dozen quadrangles in the Main Bituminous coal field of western Pennsylvania.

A large part of Pennsylvania has been mapped in varying detail and its coal reserves have been estimated, yet there are many unknowns remaining that face those responsible for developing coal. Many portions of the State should now be mapped in sufficient detail to allow more accurate estimates to be made of the remaining coal resources. Much mapping of coal in the Commonwealth has been based on the assumption that coal seams are continuous and can be traced for many miles. This assumption is true for some seams, but research in recent years has shown that some coals are discontinuous and lens-like in their distribution.

The Pennsylvania Geological Survey is currently engaged in very detailed coal mapping and data compilation. In this age of very rapid handling of large amounts of data, computers are being used to store, retrieve, and evaluate our coal data. The Pennsylvania Survey is a participant in the U. S. Geological Survey's National Coal Resources Data System (NCRDS). This federally supported project is designed to arrive, through a complex computer system, at coal resource estimates that are accurate and easily revised. Results of this project will include new coal thickness maps, resource and mined-out area maps, overburden thickness maps, sulfur trend maps, heat value maps, ash content maps, trace element trend maps, interburden character and thickness maps, structure contour maps, stratigraphic correlation diagrams, coal resource tabulations, and coal analysis tabulations. All these are to be produced on a coal-by-coal, county-by-county basis. It should also be noted that detailed field mapping in the Eastern Middle and Northern Anthracite fields is currently being continued by the Pennsylvania Survey, and Atlas maps in that area will be produced on a quadrangle-by-quadrangle basis.

Where do we go from here? Once every coal-bearing county in Pennsylvania has been analyzed, is that the end of the Survey's responsibility? Certainly not. As geologists, we recognize that our science is dynamic, and that concepts change. As we and other members of our profession learn more about the origin of coal deposits, our ability to predict the locations of these deposits grows. Add to our own growing knowledge a growth in the technology of coal mining and coal processing, and we will see thinner coals developed, deeper coals explored, and the problems of coal discontinuities solved. As petroleum and natural-gas supplies are depleted and Americans turn to coal liquefaction and gasification, the need for accurate mapping and characterization of coal will soar. The need for coal for metallurgical purposes will certainly increase, and many new analyses will be required.

The goals of the Pennsylvania Geological Survey are based on an increasing need for geological information in the Commonwealth. The increasing need is due to the ever-growing pace in land use planning, economic development, and environmental quality control. With respect to coal, the Survey's goal is to gather, analyze, interpret, and disseminate data on this valuable resource. Our objectives include continued data collection, detailed field mapping, and regional investigations, coupled with accelerated data handling by computer. Our objectives also include development of the capacity to predict coal occurrence and character accurately. In communication, our objective is to present our geologic data to the largest number of users in understandable reports and maps as rapidly as possible, without sacrificing necessary detail and accuracy.

In working toward the goal of accurately identifying the location, quantity, and quality of Pennsylvania coal, the Survey will keep abreast of new problems that will surely face development of coal and that may have geological solutions.

STRATIGRAPHIC POSITION OF PENNSYLVANIA'S MAJOR BITUMINOUS COAL SEAMS

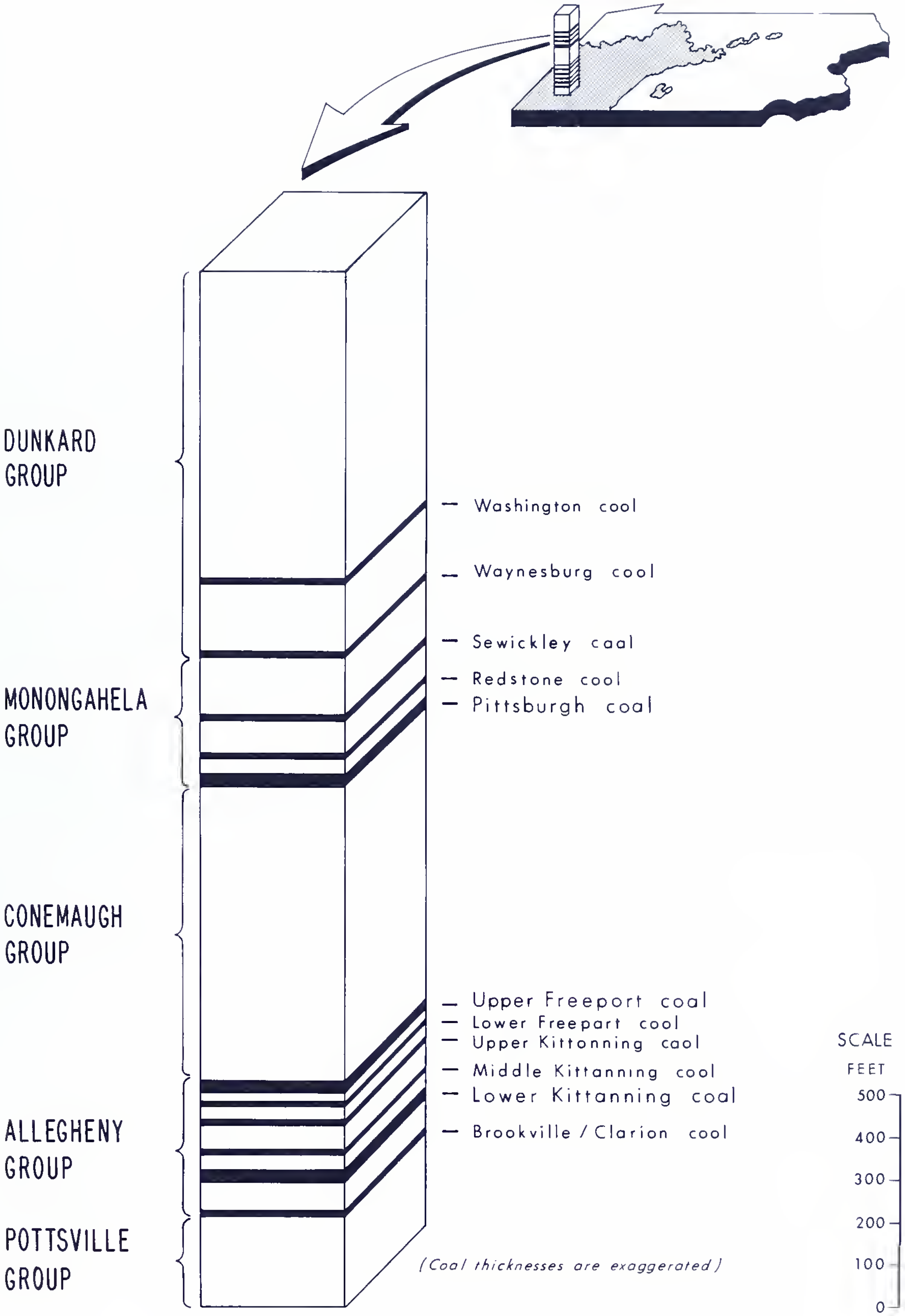
A large part of western Pennsylvania is underlain by coal-bearing strata. The coal was deposited in great swamps many millions of years ago when the climate was almost tropical and plant life was lush. The swamps sometimes covered many hundreds of square miles; sometimes they were more spotty in their distribution. When the swamps died, or shifted because of small changes in the environment, the thick accumulations of decaying organic material were covered by mud from inland seaways, or by sand from river and delta systems.

Throughout the long history of the time interval known as the Pennsylvanian Period (325 to 285 million years ago), the coal swamps grew, matured, and died many times, each time being buried by sand or mud. At the same time, the great downwarp in the earth's crust called the "Appalachian Basin" continued to sink and accumulate coal and sediment. The resulting succession of rock strata that we see preserved in western Pennsylvania today is the record of many cycles of sediment deposition punctuated by coal seams of varying thickness and extent.

The thickest and most economically important concentrations of bituminous coal seams fall into what early geologists called the "lower productive measures" and the "upper productive measures." Today, following modern geologic practice, these strata are called the Allegheny Group and the Monongahela Group. There are coal-bearing strata above and below the Allegheny and Monongahela Groups, but the economic potential is much less because the coals tend to be thinner and much more discontinuous. The Pottsville Group is the oldest, and occurs below the Allegheny Group. The Conemaugh Group falls between the Allegheny and Monongahela Groups. The Dunkard Group is the youngest, and rests above the Monongahela.

The Allegheny Group contains the Brookville/Clarion coals and the Kittanning and Freeport coals. Sometimes letters are used to refer to Allegheny Group coals (A, B, C, C′, D, and E; A being the Brookville/Clarion coal). The Monongahela Group contains the famous Pittsburgh coal at the base; the Redstone, Sewickley, and Waynesburg coals occur above the Pittsburgh. Other minor coals, too numerous to name here, occur in between the major coals just listed.

The vertical sequence of the coals and the intervening strata, as shown in the column, is very important when it comes to mining. Misidentification of a coal can lead to overlooking an important, more deeply buried seam. Misidentification of a seam can also lead to wasted exploration efforts, which are necessarily very expensive. Geologists, therefore, put much effort into learning how to identify coal seams and the intervening strata. Analysis of vertical sequences is one of the important tasks of the coal geologists at the Pennsylvania Geological Survey.



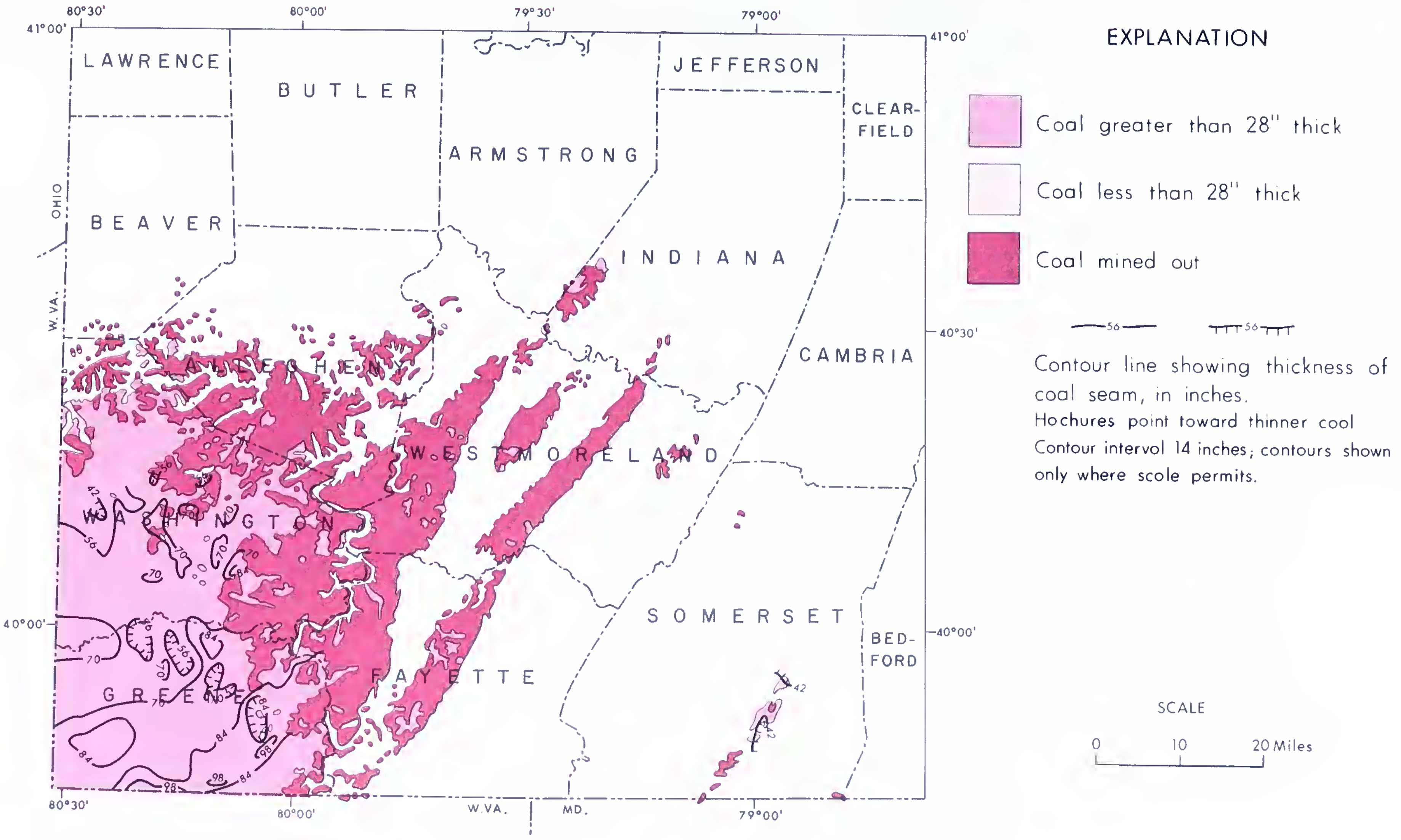
STRATIGRAPHIC POSITION OF PENNSYLVANIA'S MAJOR BITUMINOUS COAL SEAMS

DISTRIBUTION AND THICKNESS OF THE PITTSBURGH COAL

The Pittsburgh coal is the best known of the Appalachian coal seams and has probably yielded a larger gross value of product than any other individual geological deposit in the world. Approximately half of the area underlain by this coal in Pennsylvania has been mined out. The remaining coal has not, up to now, been developed, largely because of its greater depth. Most of this deeper Pittsburgh coal underlies much of Greene and Washington Counties in the southwestern corner of the State.

Minable thicknesses of the remaining Pittsburgh coal range from 28 to 110 inches, averaging about 75 inches. In approximately one half of the area underlain by the Pittsburgh, the coal occurs in benches 6 to 8 feet thick. The thicker coal occurs mainly in Greene County.

In general, the thickness of the Pittsburgh coal increases toward the south. A narrow and unusual zone of thin coal (less than 28 inches thick) cuts diagonally from southeastern Greene County to northwestern Washington County.



DISTRIBUTION AND THICKNESS OF THE PITTSBURGH COAL

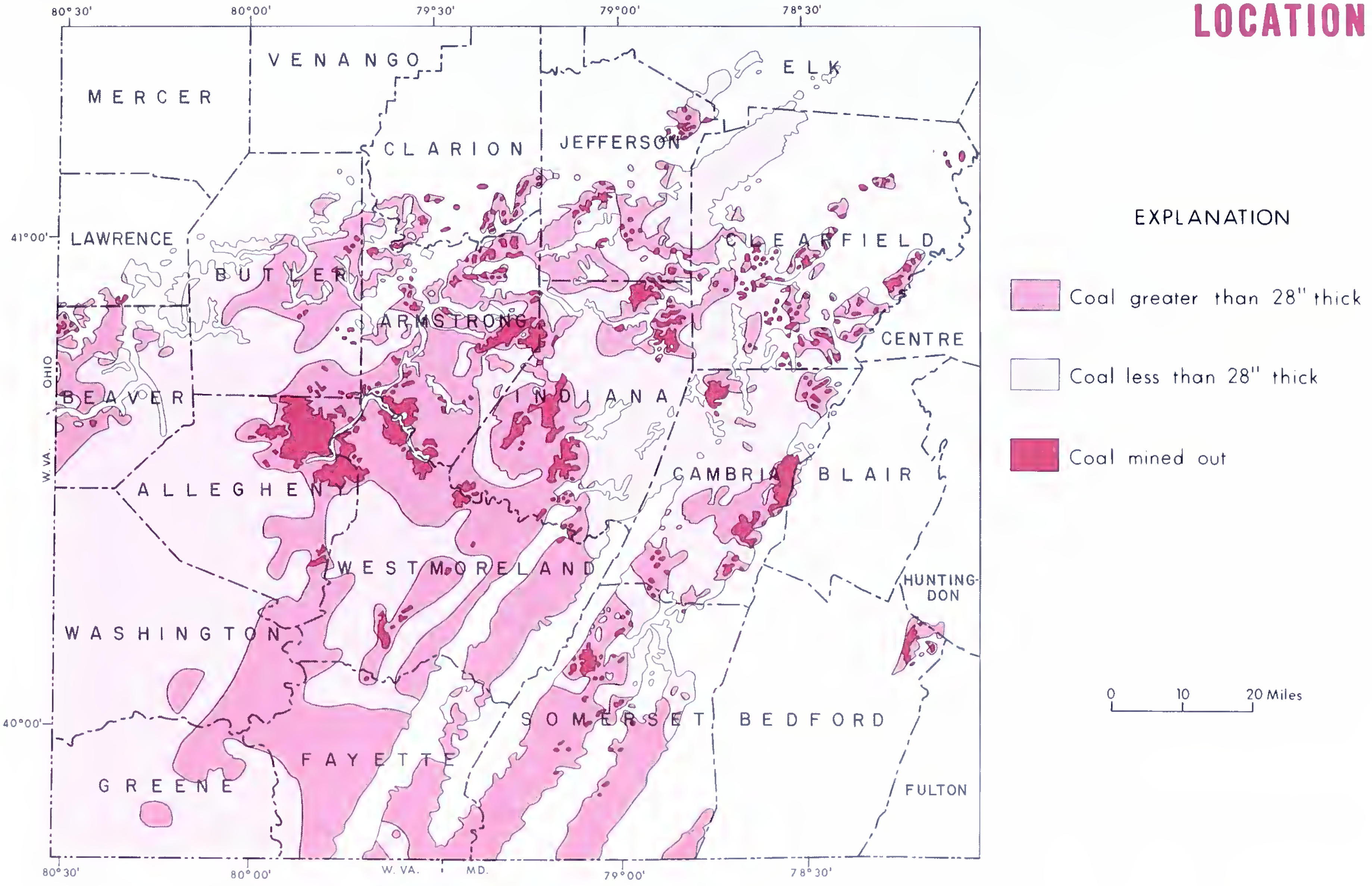
Compiled from data in files of the Pennsylvania Geological Survey
and from Pennsylvania Geological Survey Mineral Resource Report 68.

DISTRIBUTION AND THICKNESS OF THE UPPER FREEPORT COAL

The Upper Freeport coal accounts for the largest reserves of any coal in Pennsylvania. It has a minable thickness of over 28 inches throughout most of the Main Bituminous coal field. It is strip mined in Butler, Armstrong, Jefferson, Indiana, Clearfield, Centre, Cambria, and Somerset Counties. Many large deep mines on the Upper Freeport coal exist in northern Allegheny, southeastern Butler, southern Armstrong, southern Indiana, and northern Westmoreland Counties. Reserves of the coal in these counties remain high. The Upper Freeport coal is generally thin only in Greene, Washington, and western Allegheny Counties. However, several minable, thick pods of limited extent have recently been discovered in this area, and further exploration may increase the known reserves of Upper Freeport coal in these southwestern counties.

The major use of the Upper Freeport coal is for power generation.

LOCATION

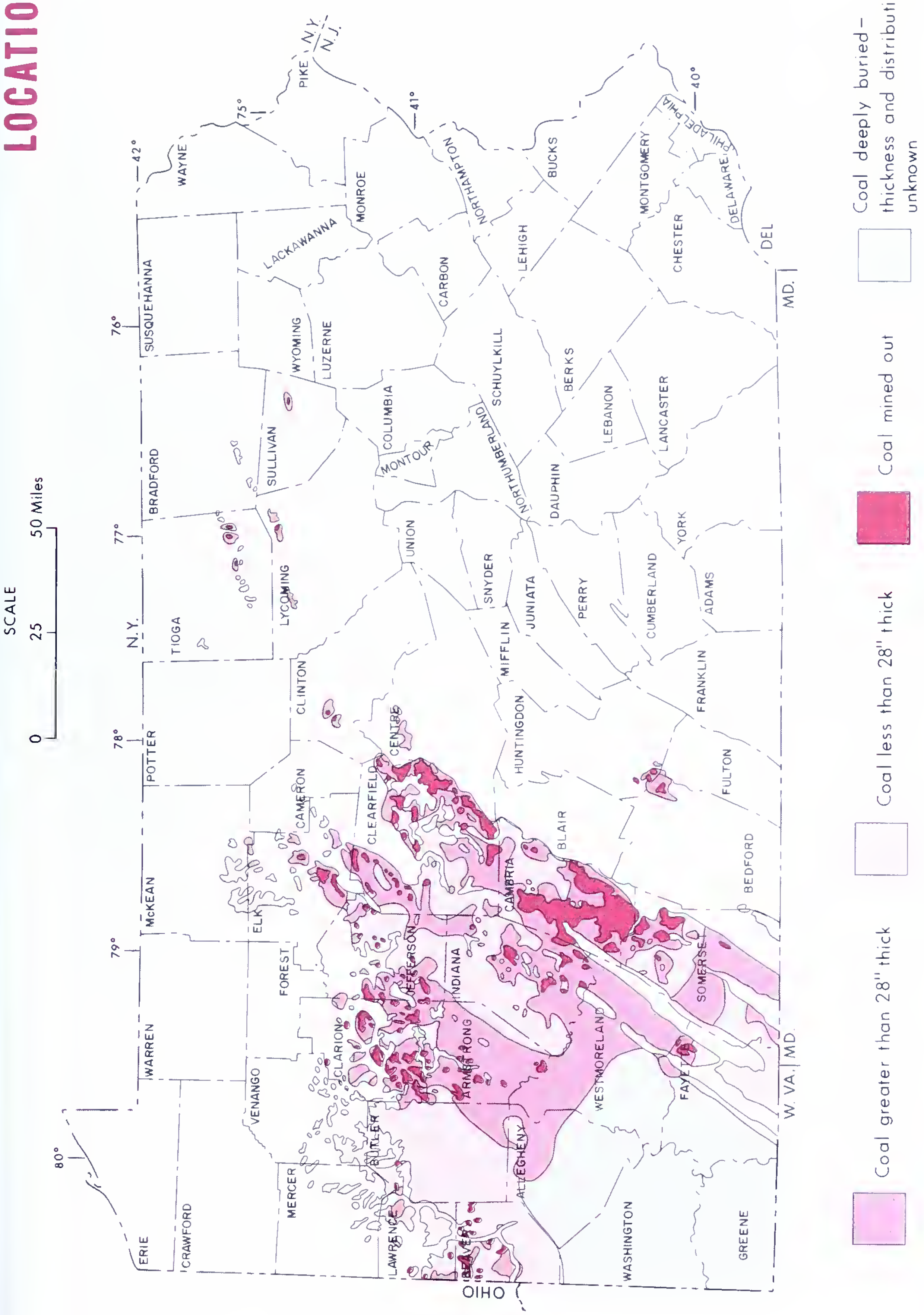


DISTRIBUTION AND THICKNESS OF THE UPPER FREEPORT COAL

Compiled from data in files of the Pennsylvania Geological Survey and from Pennsylvania Geological Survey Mineral Resource Report 68.

DISTRIBUTION AND THICKNESS OF THE LOWER KITTANNING COAL

The Lower Kittanning coal is one of the major bituminous coals in Pennsylvania. Large areas of the bituminous coal fields are underlain by minable Lower Kittanning coal, having a thickness exceeding 28 inches. The coal is widely strip mined in parts of Somerset, Cambria, Clearfield, Centre, Clinton, Elk, Jefferson, Clarion, Armstrong, Lawrence, Beaver, Lycoming, Sullivan, and Tioga Counties. It is deep mined in Cambria, Somerset, Indiana, and Clearfield Counties. Large reserves of the coal still remain in these counties. Little is known about the Lower Kittanning coal in Greene, Washington, Allegheny, western Fayette, and western Westmoreland Counties, where this seam is deeply buried, generally to depths exceeding 1,000 feet. The Lower Kittanning coal is a prime target for future exploration in these southwestern counties and could yield large quantities of bituminous coal.



DISTRIBUTION AND THICKNESS OF THE LOWER KITTANNING COAL

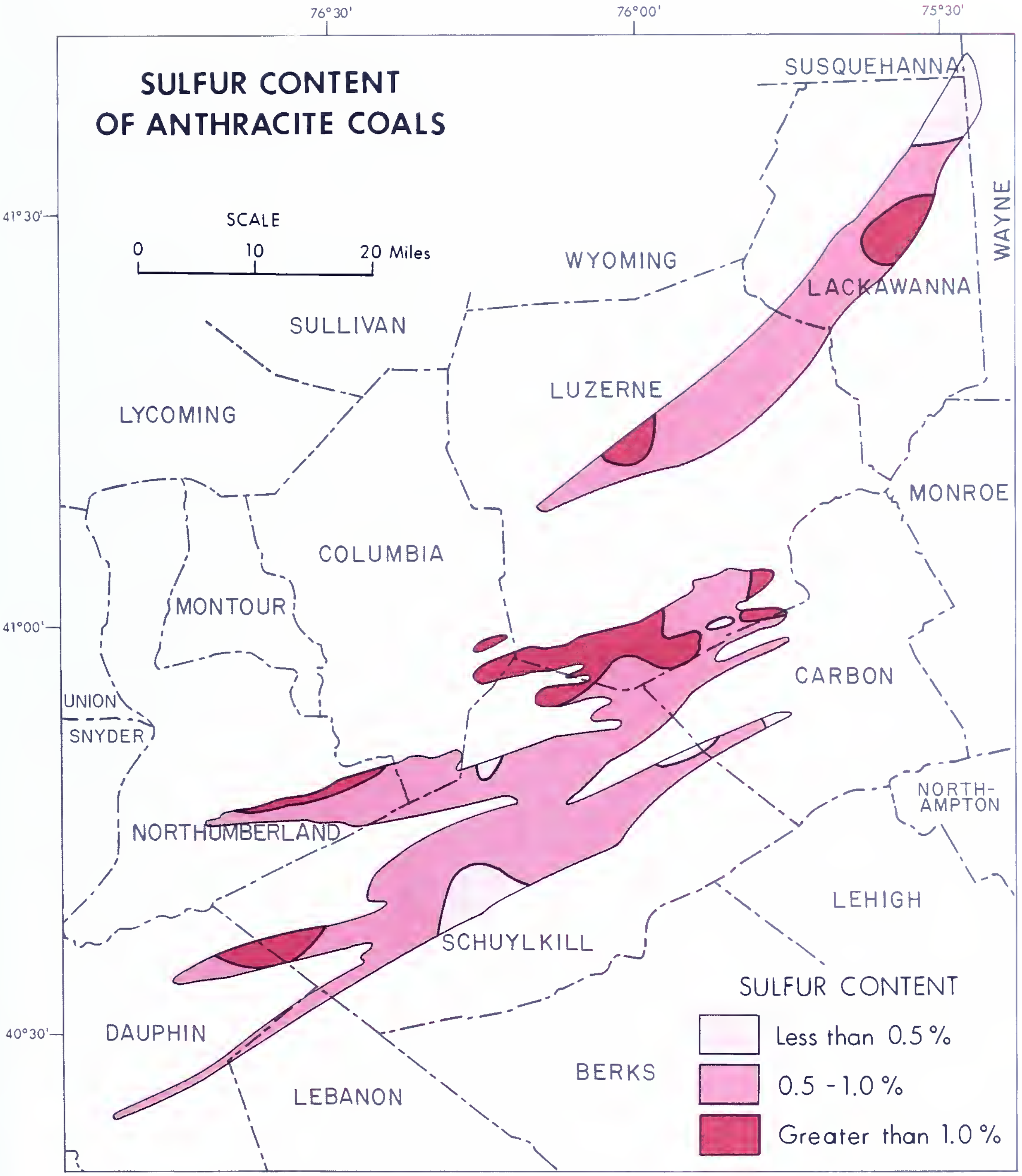
Compiled from data in files of the Pennsylvania Geological Survey and from Pennsylvania Geological Survey Mineral Resource Report 68.

SULFUR CONTENT OF ANTHRACITE COALS

The sulfur content of Pennsylvania anthracite as it comes from the mine generally ranges from 0.3 to 1.2 percent on an as-received basis (for almost 90 percent of samples analyzed). In a few local instances amounts may exceed 2 and even 3 percent.

As illustrated by the map, much Pennsylvania anthracite has a sulfur content averaging between 0.5 and 1 percent. Average sulfur content tends to be lower in the southeastern part of the combined Southern and Middle fields and higher in the western portions of those fields. In the Northern field, the average sulfur content tends to be more geographically intermixed.

Pennsylvania anthracite is one of the largest reserves of low-sulfur coal in the eastern United States. Its use for power generation may be preferable to other eastern low-sulfur coal sources, because anthracite does not have the multiple uses that much of the bituminous coal has. Its proximity to other eastern, urban-area markets is important in view of the need for low-sulfur fuel in this region.



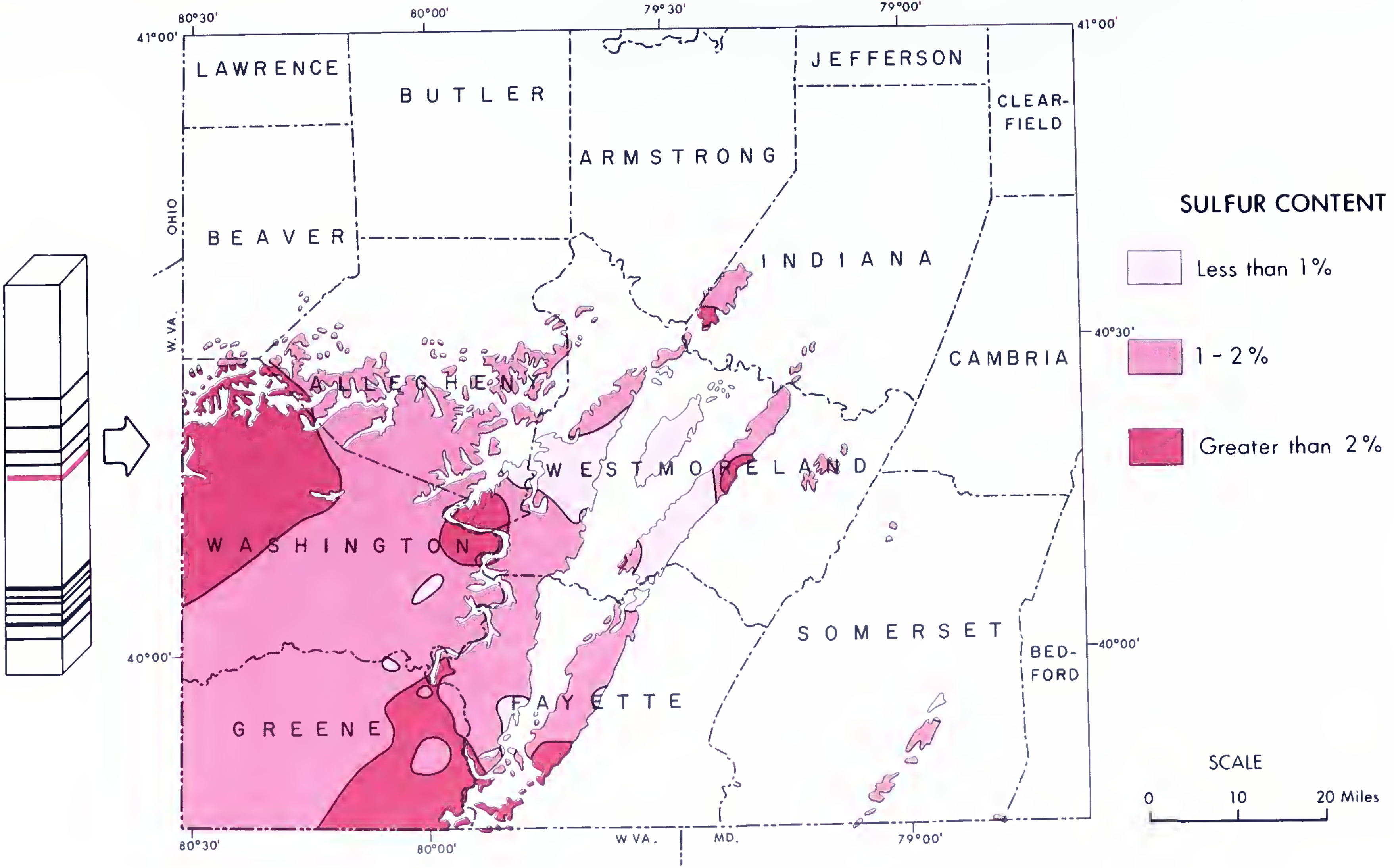
Based on data published by the U.S. Bureau of Mines (U.S.B.M. Technical Paper 659) and the U.S. Geological Survey (Open-File Report 76-468).

SULFUR CONTENT OF THE PITTSBURGH COAL

In contrast to other coals in western Pennsylvania, the amount of sulfur in the Pittsburgh coal rarely exceeds 3 percent, and generally ranges from 1 to 2 percent.

The map shows an area of low-sulfur coal (less than 1 percent) in Westmoreland County, and small patches of low-sulfur coal elsewhere. There is an area of high-sulfur coal (greater than 2 percent) in northwestern Washington County and another in southeastern Greene and southwestern Fayette Counties; smaller areas occur elsewhere. Over the remainder of the map, the amount of sulfur in the Pittsburgh coal ranges from 1 to 2 percent, a very desirable and relatively low sulfur value.

Because of its widespread occurrence, its fairly uniform and considerable thickness, and its very desirable low sulfur content, the Pittsburgh seam is one of the most important of our coal resources.



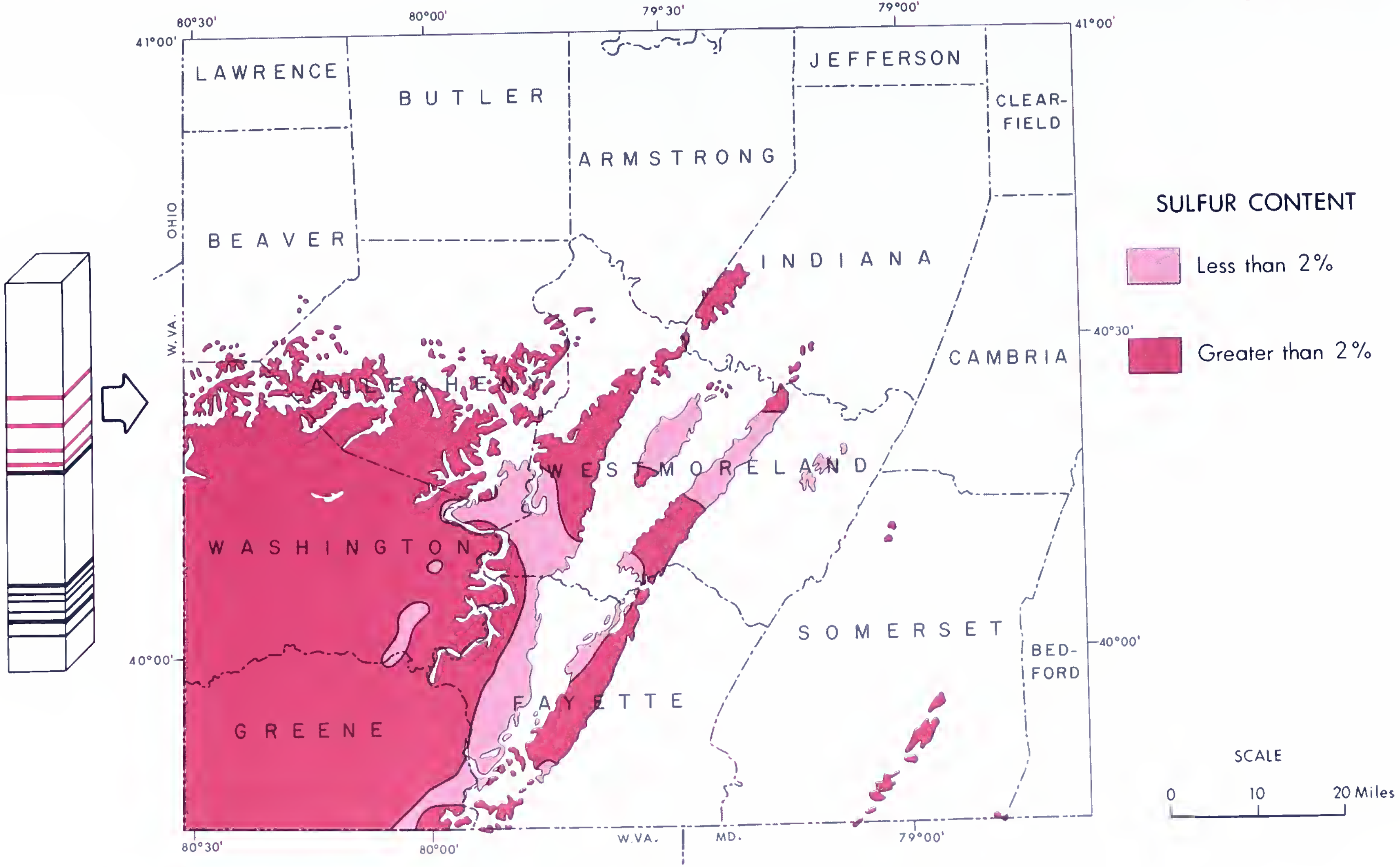
SULFUR CONTENT OF THE PITTSBURGH COAL

Based on data in files of Pennsylvania Geological Survey and an U. S. Bureau of Mines analyses of channel samples from deep mines.

SULFUR CONTENT OF COALS ABOVE THE PITTSBURGH SEAM

The coals above the Pittsburgh coal include the Redstone, Sewickley, Waynesburg, and Washington coals. The Waynesburg and Washington coals are characterized by high sulfur content (2 to 5 percent) and high ash content (15 to 20 percent) and are found mostly in Washington and Greene Counties. The amount of sulfur in the Redstone and Sewickley coals generally ranges from 1.5 to 3.0 percent. These coals have a wider distribution in Pennsylvania, being found in Allegheny, Westmoreland, and Fayette Counties, in addition to Washington and Greene Counties.

The map shows an area in eastern Westmoreland County where the sulfur in the coal is less than 2 percent. Another area of less than 2 percent sulfur is shown in southwestern Westmoreland, southern Allegheny, and western Fayette Counties, and small areas occur in eastern Washington County. Elsewhere the amount of sulfur in these coals is greater than 2 percent.



SULFUR CONTENT OF COALS ABOVE THE PITTSBURGH SEAM

Based on data in files of Pennsylvania Geological Survey and on U.S. Bureau of Mines analyses of channel samples from deep mines.

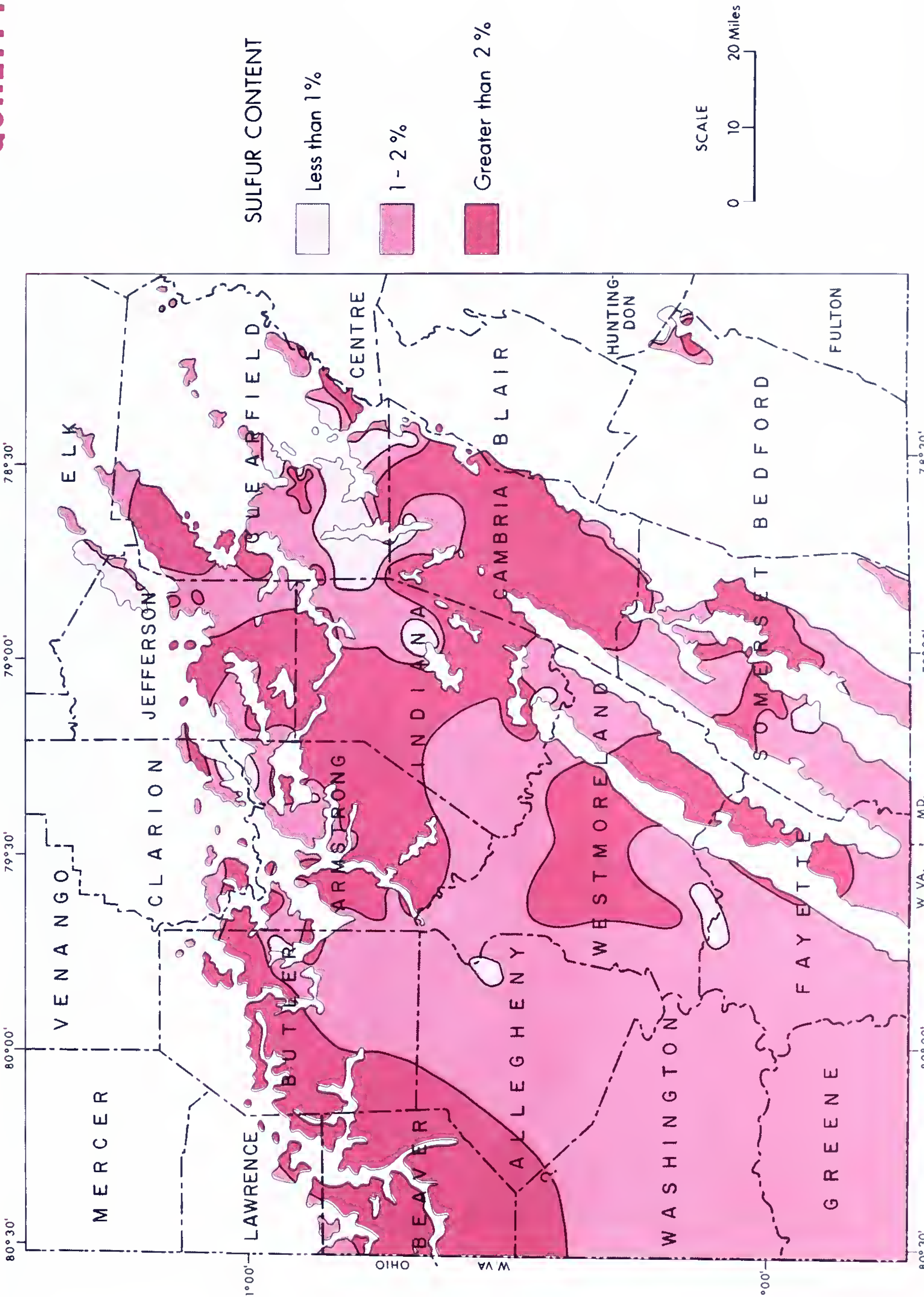
SULFUR CONTENT OF COALS IN THE UPPER PART OF THE ALLEGHENY GROUP

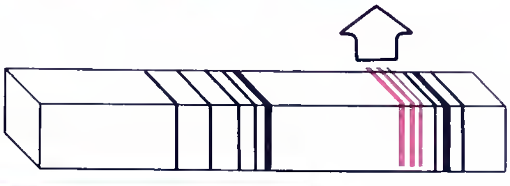
Included in this series of coals are the Upper Kittanning, Lower Freeport, and Upper Freeport coals. The amount of sulfur in these coals is generally greater than 1 percent, averaging from 1 to 3.5 percent, but locally ranging up to 6 percent or more.

As seen on the map, there is an area in southern Clearfield County of low-sulfur coal (less than 1 percent), and a few small areas of low-sulfur coal occur elsewhere. The areas of high-sulfur coal (greater than 2 percent) include Beaver, southeastern Lawrence, and central Butler Counties, much of Armstrong County, southern Jefferson, northwestern Clearfield, central Indiana and Cambria Counties, and portions of Westmoreland, Fayette, and Somerset Counties. Elsewhere the amount of sulfur in these coals ranges from 1 to 2 percent.

These coals are used mainly in power generation, but some have limited use for metallurgical purposes or as house coal.

QUALITY





Based on data in files of Pennsylvania Geological Survey and on U.S. Bureau of Mines analyses of channel samples from deep mines.

SULFUR CONTENT OF THE UPPER KITTANNING, LOWER FREEPORT, AND UPPER FREEPORT COALS

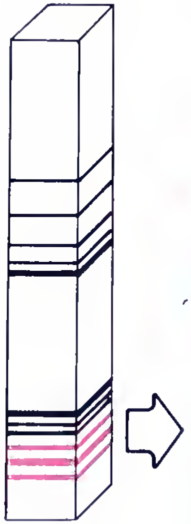
SULFUR CONTENT OF COALS IN THE LOWER PART OF THE ALLEGHENY GROUP

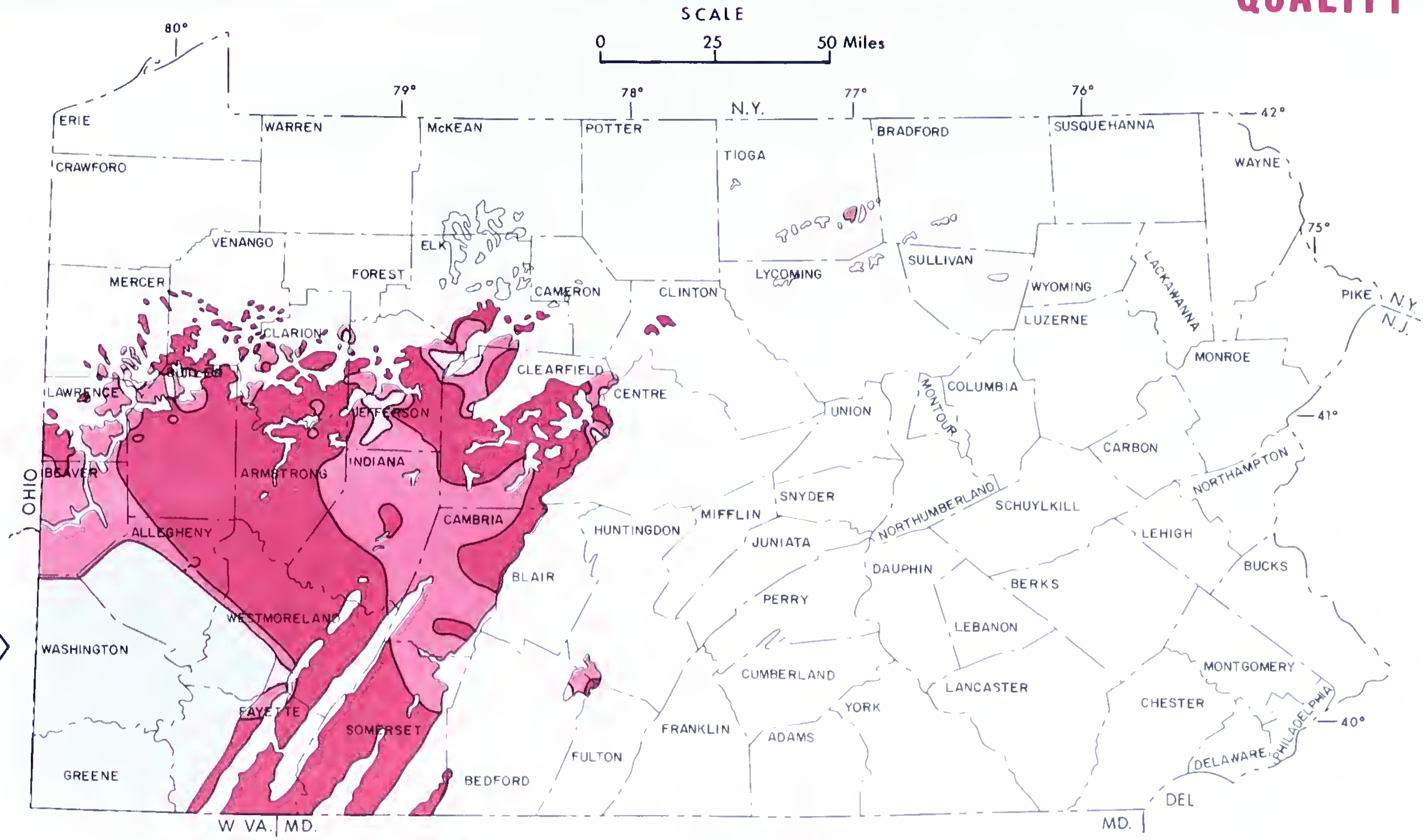
This series of coals includes the Brookville/Clarion, Lower Kittanning, and Middle Kittanning coals. The amount of sulfur in these coals generally exceeds 1 percent, ranging from 2 to 4 percent, and rarely exceeding 7 percent. Thus, these coals generally have a higher amount of sulfur than other coals in Pennsylvania.

The map shows small areas of low-sulfur coal (less than 1 percent) in Mercer, Jefferson, Clearfield, Elk, Centre, Lycoming, Westmoreland, Tioga, Sullivan, and Bedford Counties. Larger areas of coals that have a sulfur content ranging between 1 and 2 percent are found in Beaver, Lawrence, Mercer, Butler, Clarion, Jefferson, Indiana, Cambria, Somerset, Westmoreland, Fayette, Clearfield, Elk, Cameron, Centre, Clinton, Bedford, and Huntingdon Counties. Most of the map area indicates a sulfur content greater than 2 percent.

The main use of these coals is in power generation. They are locally used as house coal, and occasionally serve as metallurgical coal.

QUALITY





SULFUR CONTENT

- ☐ Less than 1%
- ▨ 1 - 2%
- 🟥 Greater than 2%
- ☐ Sulfur content unknown

SULFUR CONTENT OF THE BROOKVILLE/CLARION, LOWER KITTANNING, AND MIDDLE KITTANNING COALS

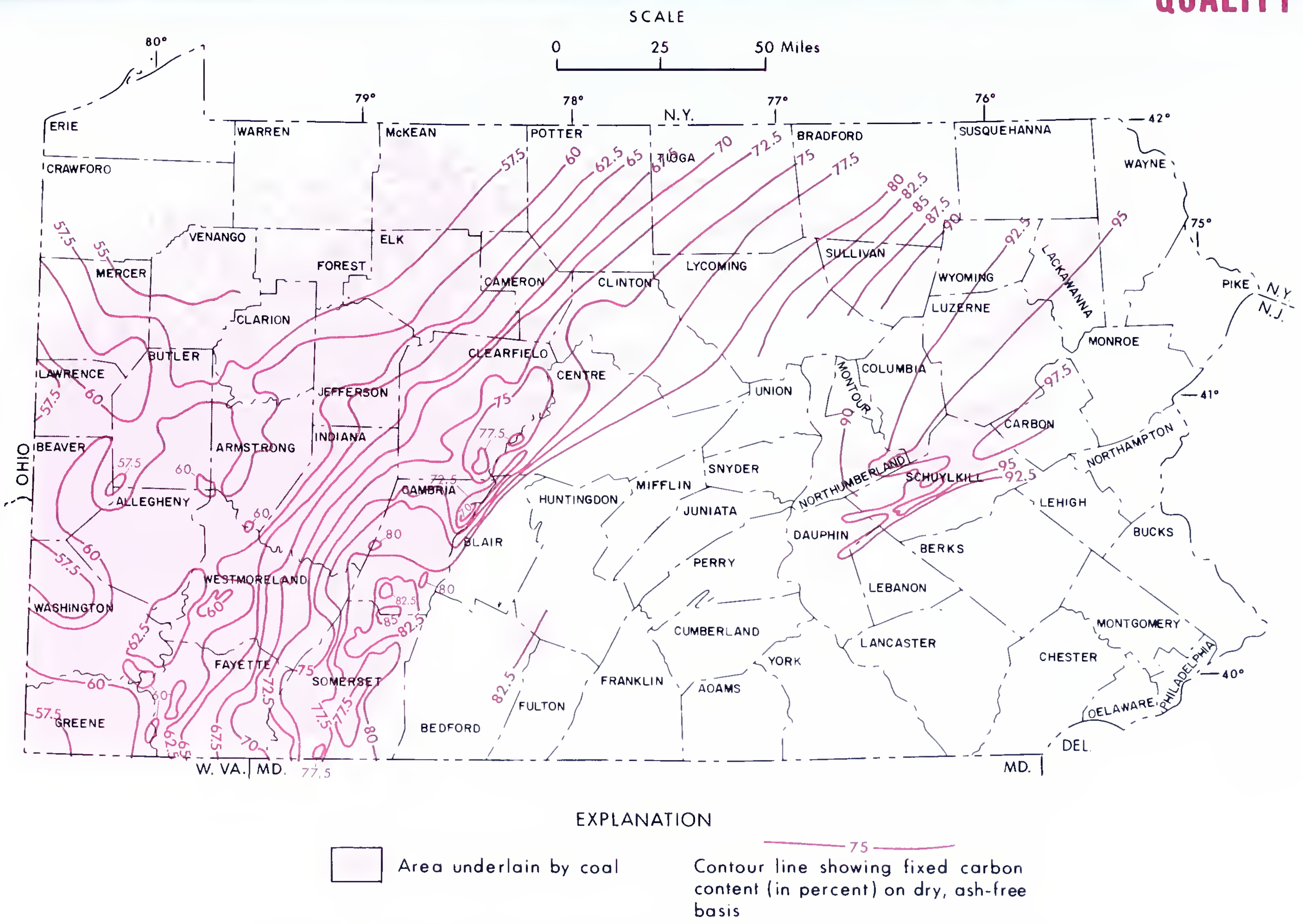
Based on data in files of Pennsylvania Geological Survey and on U. S. Bureau of Mines analyses of channel samples from deep mines.

DISTRIBUTION OF FIXED CARBON IN PENNSYLVANIA COALS

Fixed carbon is the stable carbon in coal that remains after burning in the absence of oxygen and after volatile matter has been driven off. Coal rank, which is related to fixed-carbon content, increases from the high-volatile bituminous coal in western Pennsylvania to anthracite in northeastern Pennsylvania. The fixed-carbon content (dry, ash-free) varies from 55 percent in the west to 98 percent in the east. This is believed to be the result of extreme heat and pressure associated with the stress of mountain building in Pennsylvania, the influence of which was strongest in the anthracite area.

Coal containing less than 69 percent fixed carbon (high-volatile bituminous coal) is limited to the western two thirds of the Main Bituminous field. Coal containing between 69 and 78 percent fixed carbon (medium-volatile bituminous coal) is found in the eastern third of the Main Bituminous field and the western half of the North-Central field. Coal having fixed carbon between 78 and 86 percent (low-volatile bituminous coal) is limited to Cambria and Somerset Counties of the Main Bituminous field, the Bradford County part of the North-Central field, and the Georges Creek and Broad Top fields. Semi-anthracite (fixed carbon between 86 and 92 percent) occurs in Wyoming and Sullivan Counties in the North-Central field and in part of the Western Middle and Southern Anthracite fields. Anthracite (fixed carbon over 92 percent) is found in most of the Western Middle and Southern Anthracite fields and is the only rank in the Eastern Middle and Northern Anthracite fields.

The variety of potential uses for coal increases as the fixed-carbon content decreases. Anthracites, which have the highest fixed-carbon content, are primarily suited for energy production by direct burning and conversion to gas. Because volatile matter increases westward across the bituminous coal fields, the range of uses for the coal also increases in that direction. In addition to energy production, the greater amount of volatile matter in western Pennsylvania bituminous coals enables production of coke, liquid fuels, organic chemicals, and many other by-products.

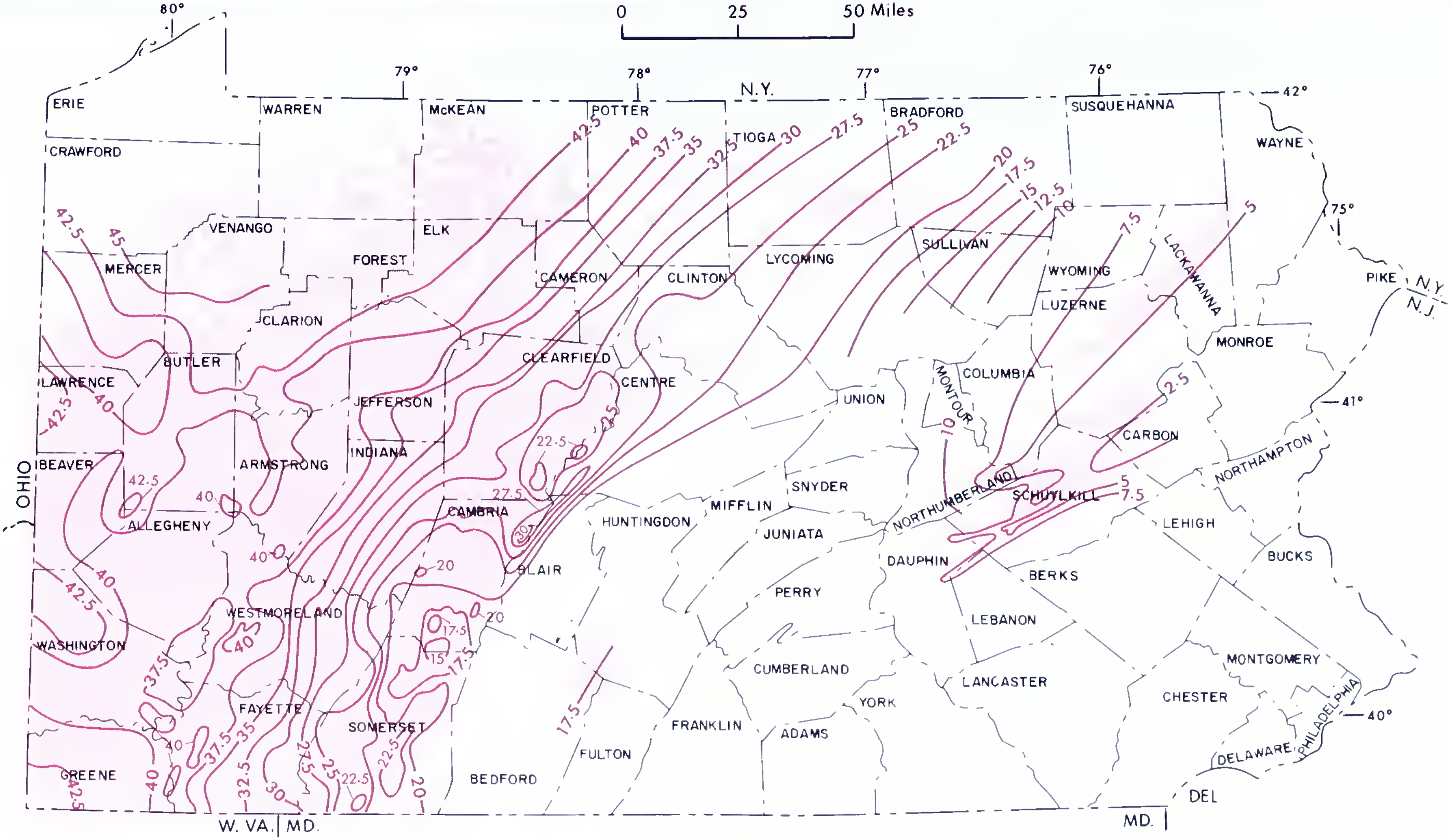


DISTRIBUTION OF FIXED CARBON IN PENNSYLVANIA COALS

Compiled from data in "1975 Keystone Coal Industry Manual," New York, McGraw-Hill Inc., p. 606.

DISTRIBUTION OF VOLATILES IN PENNSYLVANIA COALS

Volatile matter is composed of compounds other than moisture in coal that can be driven off by burning in the absence of oxygen. These come off as tars, oils, and gases. The percent of volatile matter is calculated by subtracting the percent of fixed carbon on a dry, ash-free basis from 100 percent. Thus, areas of low volatile content have high fixed carbon, whereas areas of higher volatile content (such as western Pennsylvania) have lower fixed-carbon values. Volatile matter is lowest in northeastern Pennsylvania and highest in western Pennsylvania, varying from 2 to 45 percent. The number of potential uses for Pennsylvania coal grows as the amount of volatile matter increases. Whereas anthracite coals are best suited for energy production by direct burning or gasification, many bituminous coals can also be used for the production of coke (which is so vital to making iron), organic chemicals, and liquid fuels.



EXPLANATION

▨ Area underlain by coal

—17.5— Contour line showing volatile content (in percent)

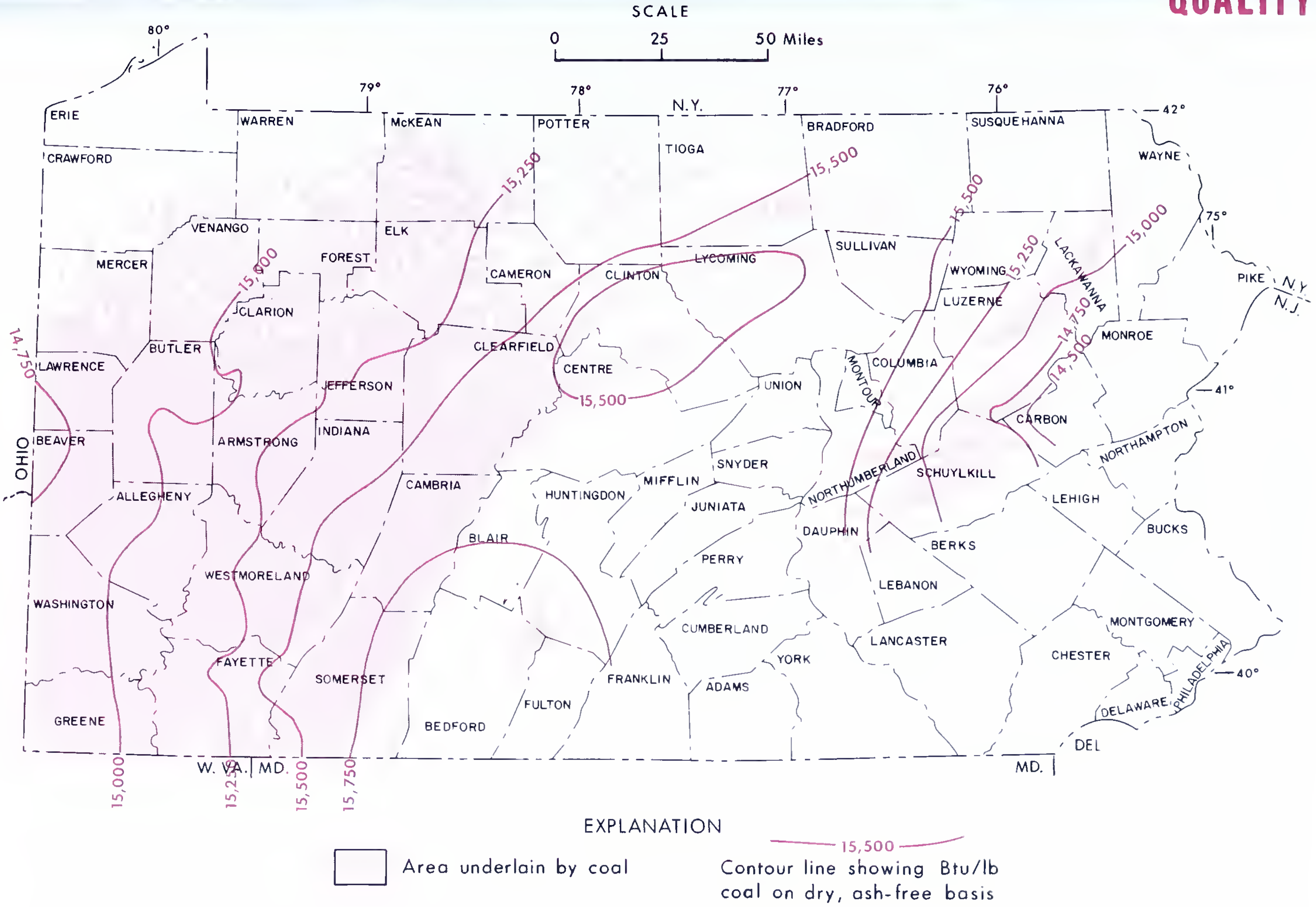
DISTRIBUTION OF VOLATILES IN PENNSYLVANIA COALS

Derived from data in "1975 Keystone Coal Industry Manual," New York, McGraw-Hill Inc., p. 606.

HEAT VALUES OF PENNSYLVANIA COALS

Heat value, expressed as British thermal units per pound (Btu/lb) on a dry, ash-free basis, indicates how much heat can be produced by a certain amount of coal. It is an important figure because the higher the heat value, the less coal is needed to produce a specified amount of heat; this is particularly important for high-volume coal users, such as in electric generating plants.

In Pennsylvania, heat value of the coals generally increases eastward with increasing coal rank in the bituminous coal fields; it then decreases farther eastward in the anthracite fields. The coal heat value increases from a low of about 14,700 Btu/lb in Beaver and Lawrence Counties to a maximum of nearly 15,800 Btu/lb in northern Somerset and southern Cambria Counties and in the Broad Top and Georges Creek areas. From this high, the heat value declines eastward with increasing rank to a minimum of about 14,400 Btu/lb in Carbon County. When coal is burned as received, it will generally yield 1000 to 3000 Btu/lb less than the dry, ash-free value.



HEAT VALUES OF PENNSYLVANIA COALS

Compiled from data in "Atlas of Pennsylvania Coal and Coal Mining, Parts 1 and 2," Pennsylvania State University Mineral Industries Experiment Station Bulletins 73 and 80; and from data in Pennsylvania Geological Survey Mineral Resource Reports 66, 69, and 74.

BIBLIOGRAPHY

BASIC REFERENCE BOOKS

Ashley, G. H. (1928), *Bituminous coal fields of Pennsylvania—Part I. General information on coal*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, 241 p., illus.

________ (1945), *Anthracite reserves*, Pennsylvania Geological Survey, 4th ser., Progress Report 130, 13 p.

Ashley, G. H., Toenges, A. L., Anderson, R. L., and others (1939), *Analyses of Pennsylvania bituminous coals*, U. S. Bureau of Mines Technical Paper 590, 503 p., illus.

Ashmead, D. C. (1926), *Anthracite losses and reserves in Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 8, 71 p., illus.

DeCarlo, J. A., Sheridan, E. T., Jr., and Murphy, Z. E. (1966), *Sulfur content of United States coals*, U. S. Bureau of Mines Information Circular 8312, 44 p., illus.

Dutcher, R. R., editor (1978), *Field description of coal* [a symposium sponsored by American Society for Testing and Materials, Ottawa, Ontario, Canada, September 22-23, 1976], Philadelphia, Pa., American Society for Testing and Materials, 71 p.

Edmunds, W. E., and Koppe, E. F. (1968), *Coal in Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Educational Series 7, 28 p., illus.

Gomez, Manuel, Donaven, D. A., and Kent, B. H. (1974), *Distribution of sulfur and ash in part of the Pittsburgh seam and probable mode of deposition*, U. S. Bureau of Mines Report of Investigations 7827, 44 p., illus.

Keystone Coal Industry Manual (published annually), New York, McGraw-Hill.

Koppe, E. F. (1960), *Coal, a petrographic approach*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 42, 35 p.

________ (1961), *Some geological factors affecting the Upper Freeport coal and its quality*, Pennsylvania Geological Survey, 4th ser., Progress Report 159, 6 p.

Lindbergh, Kristina, and Provoise, Barry (1977), *Coal, a contemporary energy story*, New York, McGraw-Hill, 207 p., illus.

Moore, E. S. (1940), *Coal, its properties, analysis, classification, geology, uses and distribution*, New York, John Wiley and Sons, illus.

Muir, W. L. G., editor (1976), *Coal exploration* [proceedings of the First International Coal Exploration Symposium, London, England, May 18-21, 1976], San Francisco, Miller Freeman Publishers, Inc., 664 p.

Pennsylvania Department of Environmental Resources (published annually), *Annual report on mining, oil and gas, and land reclamation and conservation activities*, Harrisburg, Department of Environmental Resources.

Pennsylvania Geological Survey (1976), *Distribution of Pennsylvania coals*, Pennsylvania Geological Survey, 4th ser., Map 11.

Reese, J. F., and Sisler, J. D. (1928), *Bituminous coal fields of Pennsylvania—Part III. Coal resources*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, 153 p., illus.

Rogers, W. P. (1978), *The coal primer*, Van Buren, Arkansas, Valley Press, Inc., 118 p., illus.

Sholes, M. A., and Skema, V. W. (1974), *Bituminous coal resources in western Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 68, 13 coal distribution maps, scale 1:250,000.

Sisler, J. D. (1924), *Bituminous coal losses and mining methods in Pennsylvania including the thickness, character, and reserves of coal*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 4, 216 p., illus.

________ (1929), *Map of the coal fields of Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Map 2, scale 1:380,160.

Sisler, J. D. (1932), *Bituminous coal fields of Pennsylvania—Part II. Detailed description of coal fields*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 5, 2nd ed., 511 p., illus.

Sisler, J. D., Fraser, Thomas, and Ashmead, D. C. (1928), *Anthracite culm and silt*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 12, 268 p., illus.

Skema, V. W., Berg, T. M., Bragonier, W. A., and others (1975), *Analyses and measured sections of Pennsylvania bituminous coals, Part II*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 69, 306 p.

Skema, V. W., Edmunds, W. E., Glover, A. D., and others (1977), *Analyses and measured sections of Pennsylvania bituminous coals, Part III*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 74, 272 p.

Snyder, N. H., and Swengle, R. J. (1942), *Analyses of Pennsylvania bituminous coals: Supplement to Technical Paper 590*, U. S. Bureau of Mines Technical Paper 645, 19 p.

Sponseller, R. D. (1973), *Analyses and measured sections of Pennsylvania bituminous coals*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 66, 479 p.

Thomson, R. D., and York, H. F. (1975), *The reserve base of U. S. coals by sulfur content (in two parts). 1. The eastern states*, U. S. Bureau of Mines Information Circular 8680, 537 p.

U. S. Bureau of Mines (1928), *Bituminous coal fields of Pennsylvania—Part IV. Coal analyses*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, 268 p.

________ (1944), *Analyses of Pennsylvania anthracite coals*, U. S. Bureau of Mines Technical Paper 659, 271 p., illus.

________ (1971), *Strippable reserves of bituminous coal and lignite in the United States*, U. S. Bureau of Mines Information Circular 8531, 148 p.

________ (1974), *The reserve base of bituminous coal and anthracite for underground mining in the eastern United States*, U. S. Bureau of Mines Information Circular 8655, 428 p.

Van Krevelen, D. W. (1961), *Coal: typology-chemistry-physics-constitution*, New York, Elsevier, 514 p., illus.

Wagner, H. C. (1953), *Constitution diagrams of Pennsylvania anthracite*, U. S. Geological Survey Bulletin 995-A, p. 1-18, illus.

PENNSYLVANIA COAL AREA REPORTS

ALLEGHENY COUNTY

Bushnell, K. O. (1975), *Map showing depths to the Pittsburgh coal bed, mining activity, and related surface subsidence, Allegheny, Washington, and Westmoreland Counties, Pa.*, U. S. Geological Survey Miscellaneous Field Studies Map MF-693-A, scale 1:125,000.

Bushnell, K. O., and Peak, J. R. (1975), *Map showing depths to the Upper Freeport coal bed, mining activity, and related surface subsidence, and the Redstone coal bed mines, Allegheny, Washington, and Westmoreland Counties, Pa.*, U. S. Geological Survey Miscellaneous Field Studies Map MF-693-B, scale 1:125,000.

Campbell, M. R. (1903), *Description of Brownsville and Connellsville quadrangles [Allegheny, Fayette, Washington, and Westmoreland Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 94, 19 p., illus., includes geologic maps, scale 1:62,500.

Cortis, S. E., Edmunds, W. E., Alexander, T. B., and Craft, J. L. (1975), *Greater Pittsburgh Region maps of mined-out areas and thickness of rock over the Pittsburgh coal*, Pennsylvania Geological Survey, 4th ser., Map 45, scale 1:125,000.

Craft, J. L., Heyman, Louis, and Piotrowski, R. G. (1976), *Greater Pittsburgh Region thickness of rock over the Upper Freeport coal*, Pennsylvania Geological Survey, 4th ser., Map 49, scale 1:125,000.

Gray, T. E., and Palowitch, E. R. (1959), *Preparation characteristics of coal from Allegheny County, Pa.*, U. S. Bureau of Mines Report of Investigations 5492, 34 p., illus.

Hughes, H. H. (1933), *Freeport quadrangle [Allegheny, Armstrong, and Westmoreland Counties]—Geology and mineral resources*, Pennsylvania Geological Survey, 4th ser., Atlas 36, 272 p., illus., includes geologic map, scale 1:62,500.

Johnson, M. E. (1929), *Pittsburgh quadrangle [Allegheny, Washington, and Westmoreland Counties]—Geology and mineral resources*, Pennsylvania Geological Survey, 4th ser., Atlas 27, 236 p., illus., includes geologic maps, scale 1:62,500.

Koppe, E. F. (1963), *Petrography of the Upper Freeport coal—Harmar and Springdale mines, Allegheny and Westmoreland Counties, Pennsylvania*, Pennsylvania Geological Survey, Mineral Resource Report 48, 43 p., illus.

Munn, M. J. (1911), *Description of the Sewickley quadrangle [Allegheny, Butler, and Beaver Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 176, 16 p., illus., includes geologic maps, scale 1:62,500.

Richardson, G. B. (1932), *Geology and coal, oil, and gas resources of the New Kensington quadrangle [Allegheny, Butler, and Westmoreland Counties], Pa.*, U. S. Geological Survey Bulletin 829, 102 p., illus., includes geologic maps.

Roen, J. B., Kent, B. H., and Schweinfurth, S. P. (1968), *Geologic map of the Monongahela quadrangle [Allegheny, Washington, and Westmoreland Counties], southwestern Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-743, scale 1:24,000, text.

Shaw, E. W., and Munn, M. J. (1911), *Description of the Burgettstown and Carnegie quadrangles [Allegheny, Beaver, and Washington Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 177, 16 p., illus., includes geologic maps, scale 1:62,500.

Wagner, W. R., Craft, J. L., Heyman, Louis, and Harper, J. A. (1975), *Greater Pittsburgh Region geologic map and cross sections*, Pennsylvania Geological Survey, 4th ser., Map 42, scale 1:125,000.

Wallace, J. J., Dowd, J. J., Provost, J. M., and others (1953), *Estimate of known recoverable reserves of coking coal in Allegheny County, Pa.*, U. S. Bureau of Mines Report of Investigations 5003, 16 p., illus.

Wolfson, D. E., and Birge, G. W. (1959), *Carbonizing properties of Allegheny County, Pa., coals*, U. S. Bureau of Mines Report of Investigations 5455, 16 p.

Woolsey, L. H. (1905), *Description of the Beaver quadrangle [Allegheny and Beaver Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 134, 15 p., illus., includes geologic maps, scale 1:62,500.

ARMSTRONG COUNTY

Butts, Charles (1904), *Description of the Kittanning quadrangle [Armstrong, Butler, and Clarion Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 115, 15 p., illus., includes geologic maps, scale 1:62,500.

________ (1905), *Description of the Rural Valley quadrangle [Armstrong and Clarion Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 125, 11 p., illus., includes geologic maps, scale 1:62,500.

Crentz, W. L., Steele, Fern, and Bailey, A. L. (1951), *Preparation characteristics of coal occurring in Armstrong County, Pa.*, U. S. Bureau of Mines Report of Investigations 4788, 25 p., illus.

Dowd, J. J., Turnbull, L. A., Toenges, A. L., and others (1951), *Estimate of known recoverable reserves of coking coal in Armstrong County, Pa.*, U. S. Bureau of Mines Report of Investigations 4801, 16 p., illus.

Smith, F. W., Wolfson, D. E., Reynolds, D. A., and others (1954), *Carbonizing properties of Armstrong County, Pa., coals*, U. S. Bureau of Mines Report of Investigations 5101, 20 p.

Zubovic, Peter, Stadnichenko, T. M., and Sheffey, N. B. (1966), *Distribution of minor elements in coals of the Appalachian region*, U. S. Geological Survey Bulletin 1117-C, p. C1-C37, illus.

See: ALLEGHENY COUNTY— Cortis, S. E., and others
Craft, J. L., and others
Hughes, H. H.
Wagner, W. R., and others
BUTLER COUNTY—Butts, Charles
CLARION COUNTY—Shaw, E. W., and others
INDIANA COUNTY—Shaffner, M. N.
Stone, Ralph (1905a)
________ (1905b)
JEFFERSON COUNTY—Graeber, C. K., and Foose, R. M.

BEAVER COUNTY

Patterson, E. D. (1963), *Coal resources of Beaver County, Pennsylvania*, U. S. Geological Survey Bulletin 1143-A, p. A1-A33, illus., includes geologic map.

Richardson, G. B. (1936), *Geology and mineral resources of the Butler and Zelienople quadrangles [Beaver, Butler, and Lawrence Counties], Pennsylvania*, U. S. Geological Survey Bulletin 873, 93 p., illus., includes geologic maps.

Woolsey, L. H. (1906), *Economic geology of the Beaver quadrangle, Pennsylvania*, U. S. Geological Survey Bulletin 286, 132 p., illus.

Zeilinger, J. E. (1969), *Preparation characteristics of coal from Beaver and Lawrence Counties, Pa.*, U. S. Bureau of Mines Report of Investigations 7324, 23 p., illus.

See: ALLEGHENY COUNTY— Cortis, S. E., and others
Craft, J. L., and others
Munn, M. J.
Shaw, E. W., and Munn, M. J.
Wagner, W. R., and others
Woolsey, L. H.
LAWRENCE COUNTY—DeWolf, F. W.

BEDFORD COUNTY

See: BLAIR COUNTY—Butts, Charles
CAMBRIA COUNTY—Butts, Charles
HUNTINGDON COUNTY—Gardner, J. H.
SOMERSET COUNTY—Richardson, G. B.

BERKS COUNTY

See: SCHUYLKILL COUNTY—Wood, G. H., Jr., and Kehn, T. M. (1968a)
________ (1968b)

BLAIR COUNTY

Ashburner, C. A. (1886), *Report on the Tipton Run coal openings, Blair County (coal beds in the Pocono Formation No. X)*, in *Annual report of the Geological Survey of Pennsylvania for 1885*, Pennsylvania Geological Survey, 2nd ser., p. 250-268.

Butts, Charles (1945), *Description of the Hollidaysburg and Huntingdon quadrangles [Blair, Bedford, and Huntingdon Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 227, 27 p., illus., includes geologic maps, scale 1:62,500.

See: CAMBRIA COUNTY—Butts, Charles
Campbell, M. R., and others

BRADFORD COUNTY

Platt, Franklin (1878), *Coal basins of Bradford and Tioga Counties, and at the forks of Pine Creek in Potter County*, in Sherwood, Andrew, Platt, Franklin, and Fulton, John, *Report of progress in Bradford and Tioga Counties*, Pennsylvania Geological Survey, 2nd ser., Report G, Part II, p. 97-234, illus.

BUTLER COUNTY

Birge, G. W., and Wolfson, D. E. (1962), *Carbonizing properties of Butler County, Pa., coals*, U. S. Bureau of Mines Report of Investigations 5927, 12 p.

Butts, Charles (1906), *Economic geology of the Kittanning and Rural Valley quadrangles [Butler, Clarion, and Armstrong Counties], Pennsylvania*, U. S. Geological Survey Bulletin 279, 198 p., illus., includes geologic map.

Chance, H. M. (1879), *Report on north Butler County*, Pennsylvania Geological Survey, 2nd ser., Report V, 248 p., illus., includes geologic map.

Gray, T. E., and Palowitch, E. R. (1960), *Preparation characteristics of coal from Butler County, Pa.*, U. S. Bureau of Mines Report of Investigations 5609, 49 p., illus.

Patterson, E. D., and Van Lieu, J. A. (1971), *Coal resources of Butler County, Pennsylvania*, U. S. Geological Survey Bulletin 1143-C, p. C1-C43, illus., includes geologic map.

See: ALLEGHENY COUNTY— Cortis, S. E., and others
Craft, J. L., and others
Munn, M. J.
Richardson, G. B.
Wagner, W. R., and others
ARMSTRONG COUNTY—Butts, Charles (1904)
BEAVER COUNTY—Richardson, G. B.
CLARION COUNTY—Shaw, E. W., and others

CAMBRIA COUNTY

Butts, Charles (1905), *Description of the Ebensburg quadrangle [Cambria, Blair, and Bedford Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 133, 9 p., illus., includes geologic maps, scale 1:62,500.

Campbell, M. R., Clapp, F. G., and Butts, Charles (1913), *Description of the Barnesboro and Patton quadrangles [Cambria, Indiana, Clearfield, and Blair Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 189, 13 p., illus., includes geologic maps, scale 1:62,500.

Crentz, W. L., and Steele, Fern (1950), *Preparation characteristics of coal occurring in Cambria County, Pa.*, U. S. Bureau of Mines Report of Investigations 4747, 40 p., illus.

Dowd, J. J., Turnbull, L. A., Toenges, A. L., and others (1950), *Estimate of known recoverable reserves of coking coal in Cambria County, Pa.*, U. S. Bureau of Mines Report of Investigations 4734, 25 p., illus.

Phalen, W. C. (1907), *Coal resources of Johnstown, Pa., and vicinity [Cambria, Somerset, Indiana, and Westmoreland Counties]*, U. S. Geological Survey Bulletin 316, p. 20-41, illus.

Shaffner, M. N. (1958), *Geology and mineral resources of the New Florence quadrangle [Cambria, Indiana, Somerset, and Westmoreland Counties], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 57, 165 p., illus., includes geologic map, scale approximately 1:84,000.

See: SOMERSET COUNTY—Phalen, W. C.
Richardson, G. B.

CAMERON COUNTY

See: ELK COUNTY—Ashburner, C. A., and Sheafer, A. W.
McKEAN COUNTY—Ashburner, C. A.

CARBON COUNTY

Ash, S. H., Kynor, H. D., Fatzinger, R. W., and others (1950), *Inundated anthracite reserves: Eastern Middle field of [northeastern] Pennsylvania*, U. S. Bureau of Mines Bulletin 491, 28 p., illus.

Wood, G. H., Jr. (1974a), *Geologic map of the anthracite-bearing rocks in the Tamaqua quadrangle, Carbon and Schuylkill Counties, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-809, scale 1:24,000.

________ (1974b), *Geologic map of the Nesquehoning quadrangle, Carbon and Schuylkill Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1132, scale 1:24,000.

________ (1974c), *Geologic map of the Tamaqua quadrangle, Carbon and Schuylkill Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1133, scale 1:24,000.

See: LUZERNE COUNTY—Hill, F. A., and others (1888)
________ (1889)
SCHUYLKILL COUNTY—Ashburner, C. A. (1883)
________ (1885)
________ (1886)
Ashburner, C. A., and others (1882)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1895)

CENTRE COUNTY

d'Invilliers, E. V. (1884), *The geology of Centre County*, Pennsylvania Geological Survey, 2nd ser., Report T4, p. 1-351, illus., includes geologic map.

See: CLEARFIELD COUNTY—Glass, G. B.
Glass, G. B., and others
ELK COUNTY—Birge, G. W., and others

CLARION COUNTY

Blaylock, D. W., Dowd, J. J., Abernethy, R. F., and Reynolds, D. A. (1956), *Estimate of known recoverable reserves of coking coal in Clarion County, Pa.*, U. S. Bureau of Mines Report of Investigations 5231, 27 p., illus.

Lines, E. F. (1907), *Coals of the Clarion quadrangle, Clarion County, Pa.*, U. S. Geological Survey Bulletin 316, p. 13-19, illus., includes map.

Patterson, E. D., and Van Lieu, J. A. (1972), *Geologic and coal-bed map of Clarion County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-715, scale 1:62,500.

Shaw, E. W., Lines, E. F., and Munn, M. J. (1911), *Description of the Foxburg and Clarion quadrangles [Clarion, Armstrong, Butler, and Venango Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 178, 17 p., illus., includes geologic maps, scale 1:62,500.

Zeilinger, J. E., and Deurbrouck, A. W. (1968), *Preparation characteristics of coal from Clarion County, Pa.*, U. S. Bureau of Mines Report of Investigations 7174, 34 p., illus.

See: ARMSTRONG COUNTY—Butts, Charles (1904)
________ (1905)
BUTLER COUNTY—Butts, Charles
ELK COUNTY—Birge, G. W., and others
JEFFERSON COUNTY—Graeber, C. K., and Foose, R. M.

CLEARFIELD COUNTY

Ashley, G. H. (1926), *Geology and mineral resources of the Punxsutawney quadrangle [Clearfield, Jefferson, and Indiana Counties], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 65, 154 p., illus., includes geologic map, scale 1:62,500.

________ (1940), *Geology and mineral resources of the Curwensville quadrangle [Clearfield County]*, Pennsylvania Geological Survey, 4th ser., Atlas 75, 140 p., illus., includes geologic map, scale 1:62,500.

Berg, T. M., and Glover, A. D. (1976), *Geology and mineral resources of the Sabula and Penfield quadrangles, Clearfield, Elk, and Jefferson Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 74ab, 98 p., illus., includes geologic map, scale 1:24,000.

Blaylock, D. W., Dowd, J. J., Abernethy, R. F., and Reynolds, D. A. (1955), *Estimate of known recoverable reserves of coking coal in Clearfield County, Pa.*, U. S. Bureau of Mines Report of Investigations 5166, 36 p., illus.

Crentz, W. L., Bailey, A. L., and Miller, J. W. (1952), *Preparation characteristics of coal from Clearfield County, Pa.*, U. S. Bureau of Mines Report of Investigations 4894, 27 p., illus.

Edmunds, W. E. (1968), *Geology and mineral resources of the northern half of the Houtzdale 15-minute quadrangle [Clearfield County], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 85ab, 150 p., illus., includes geologic map, scale 1:24,000.

Edmunds, W. E., Berg, T. M., and Darrah, W. C. (1971), *Geology and mineral resources of the southern half of the Penfield 15-minute quadrangle [Clearfield County], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 74cd, 184 p., illus., includes geologic map, scale 1:24,000.

Glass, G. B. (1972), *Geology and mineral resources of the Philipsburg 7-1/2-minute quadrangle [Clearfield and Centre Counties], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 95a, 241 p., illus., includes geologic map, scale 1:24,000.

Glass, G. B., Edmunds, W. E., Shepps, V. C., and others (1977), *Geology and mineral resources of the Ramey and Houtzdale quadrangles, Clearfield and Centre Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 85cd, 94 p., illus., includes geologic map, scale 1:24,000.

Glover, A. D. (1970), *Geology and mineral resources of the southern half of the Clearfield 15-minute quadrangle [Clearfield County], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 84cd, 139 p., illus., includes geologic map, scale 1:24,000.

Glover, A. D., and Bragonier, W. A. (1978), *Geology and mineral resources of the Hazen, Falls Creek, Reynoldsville, and DuBois quadrangles, Clearfield and Jefferson Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 64, 131 p., illus., includes geologic map, scale 1:24,000.

Koppe, E. F. (1967), *Petrography of coal in the Houtzdale quadrangle, Clearfield County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 55, 73 p.

See: CAMBRIA COUNTY—Campbell, M. R., and others
ELK COUNTY—Birge, G. W., and others

CLINTON COUNTY

Chance, H. M. (1880), *The geology of Clinton County*, Pennsylvania Geological Survey, 2nd ser., Report G4, 183 p., illus., includes geologic map.

COLUMBIA COUNTY

Arndt, H. H. (1971a), *Geologic map of the Ashland quadrangle, Columbia and Schuylkill Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-918, scale 1:24,000.

________ (1971b), *Geologic map of the Mount Carmel quadrangle, Columbia, Northumberland, and Schuylkill Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-919, scale 1:24,000.

Haley, B. R. (1954), *Geology of anthracite in the eastern part of the Ashland quadrangle [Columbia and Schuylkill Counties], Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-14, 2 sheets, scale 1:12,000, includes sections and text.

Haley, B. R., Arndt, H. H., Rothrock, H. E., and Wagner, H. C. (1953), *Geology of anthracite in the western part of the Ashland quadrangle [Columbia and Schuylkill Counties], Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-13, 2 sheets, scale 1:12,000, includes sections and text.

Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H. (1951), *Geology of anthracite in the east-central part of the Mount Carmel quadrangle [Columbia and Northumberland Counties], Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-10, 3 sheets, scale 1:6,000, includes sections and text.

________ (1953), *Geology of anthracite in the southeastern part of the Mount Carmel quadrangle [Columbia, Northumberland, and Schuylkill Counties], Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-12, 3 sheets, scale 1:6,000, includes sections and text.

See: LUZERNE COUNTY—Hill, F. A., and others (1889)
NORTHUMBERLAND COUNTY—Arndt, H. H., and others (1973)
Hill, F. A., and others (1887)
________ (1891)
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A., and others (1884)
________ (1887)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1895)

DAUPHIN COUNTY

Trexler, J. P., and Wood, G. H., Jr. (1968), *Geologic map of the Lykens quadrangle, Dauphin, Schuylkill, and Lebanon Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-701, scale 1:24,000.

Wood, G. H., Jr., and Trexler, J. P. (1968), *Geologic map of anthracite-bearing rocks in the west-central part of the Southern Anthracite field [Dauphin, Lebanon, and Schuylkill Counties], Pennsylvania, western area*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-529, 4 sheets, scale 1:12,000.

Wood, G. H., Jr., Trexler, J. P., and Kehn, T. M. (1968), *Geologic map of anthracite-bearing rocks in the west-central part of the Southern Anthracite field [Dauphin, Lebanon, and*

Schuylkill Counties], Pennsylvania, eastern area, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-528, 6 sheets, scale 1:12,000.

See: NORTHUMBERLAND COUNTY—Trexler, J. P., and Wood, G. H., Jr.
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A., and others (1887)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1891b)
________ (1895)
Smith, A. D. W., and others (1889b)
________ (1891)
Smith, A. D. W., and Wright, C. J.
Wood, G. H., Jr. (1968)

ELK COUNTY

Ashburner, C. A., and Sheafer, A. W. (1885), *The township geology of Elk and Forest Counties, and of Cameron County*, Pennsylvania Geological Survey, 2nd ser., Report RR, Part II, p. 61-299, illus., includes geologic maps.

Birge, G. W., Wolfson, D. E., and Lynch, J. H., Jr. (1963), *Carbonizing properties of coals from Elk, Clarion, Jefferson, Clearfield, and Centre Counties, Pa.*, U. S. Bureau of Mines Report of Investigations 6261, 22 p.

See: CLEARFIELD COUNTY—Berg, T. M., and Glover, A. D.
McKEAN COUNTY—Ashburner, C. A.

FAYETTE COUNTY

Campbell, M. R. (1902), *Description of the Masontown and Uniontown quadrangles [Fayette, Greene, and Washington Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 82, 21 p., illus., includes geologic maps, scale 1:62,500.

Crentz, W. L., Bailey, A. L., and Miller, J. W. (1951), *Preparation characteristics of coal from Fayette County, Pa.*, U. S. Bureau of Mines Report of Investigations 4815, 16 p., illus.

Dowd, J. J., Turnbull, L. A., Toenges, A. L., and others (1951), *Estimate of known recoverable reserves of coking coal in Fayette County, Pa.*, U. S. Bureau of Mines Report of Investigations 4807, 19 p., illus.

Hickok, W. O., IV, and Moyer, F. T. (1940), *Geology and mineral resources of Fayette County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., County Report 26, 530 p., illus.

Kent, B. H. (1969a), *Geologic map of part of the Carmichaels quadrangle [Fayette, Greene, and Washington Counties], southwestern Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-588, scale 1:24,000, includes text.

________ (1969b), *Geologic map of the Mather quadrangle [Fayette, Greene, and Washington Counties], southwestern Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-826, scale 1:24,000, includes text.

Martin, G. C. (1908), *Description of the Accident and Grantville quadrangles [Fayette and Somerset Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 160, 14 p., illus., includes geologic maps, scale 1:62,500.

Shaffner, M. N. (1963), *Geology and mineral resources of the Donegal quadrangle [Fayette, Somerset, and Westmoreland Counties], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 48, 116 p., illus., includes geologic map, scale 1:62,500.

Steidl, P. F. (1977), *Geology and methane content of the Upper Freeport coalbed in Fayette County, Pa.*, U. S. Bureau of Mines Report of Investigations 8226r, 17 p., illus.

Wolfson, D. E., and Ortuglio, Carmen (1968), *Carbonizing properties of coals from Fayette, Greene, and Washington Counties, Pa.*, U. S. Bureau of Mines Report of Investigations 7131, 14 p.

See: ALLEGHENY COUNTY—Campbell, M. R.
GREENE COUNTY—Stone, R. W. (1905)
WASHINGTON COUNTY—Schweinfurth, S. P. (1967a)

FOREST COUNTY

See: ELK COUNTY—Ashburner, C. A., and Sheafer, A. W.
McKEAN COUNTY—Ashburner, C. A.

FULTON COUNTY

See: HUNTINGDON COUNTY—Gardner, J. H.

GREENE COUNTY

Clapp, F. G. (1907), *Description of the Rogersville quadrangle [Greene and Washington Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 146, 14 p., illus., includes geologic maps, scale 1:62,500.

Gray, T. E., and Palowitch, E. R. (1958), *Preparation characteristics of coal from Greene County, Pa.*, U. S. Bureau of Mines Report of Investigations 5434, 31 p., illus.

Kent, B. H. (1971), *Geologic map of the Garards Fort quadrangle and part of the Osage quadrangle, Greene County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-663, scale 1:24,000.

________ (1973), *Geologic map of parts of the Masontown and Morgantown North quadrangles, Greene County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-743, scale 1:24,000.

Munn, M. J. (1912), *Description of the Claysville quadrangle [Greene and Washington Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 180, 14 p., illus., includes geologic maps, scale 1:62,500.

Roen, J. B. (1970), *Geologic map of the Waynesburg quadrangle [Greene County], southwestern Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-838, scale 1:24,000.

________ (1972), *Geologic map of the Oak Forest quadrangle and part of the Blacksville quadrangle [Greene County], southwestern Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-699, scale 1:24,000.

Stone, R. W. (1905), *Description of the Waynesburg quadrangle [Greene, Washington, and Fayette Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 121, 12 p., illus., includes geologic map, scale 1:62,500.

________ (1932), *Geology and mineral resources of Greene County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., County Report 30, 175 p., illus., includes geologic map, scale approximately 1:125,000.

Wallace, J. J., Dowd, J. J., Provost, J. M., and others (1955), *Estimate of known recoverable reserves of coking coal in Greene County, Pa.*, U. S. Bureau of Mines Report of Investigations 5143, 22 p., illus.

See: FAYETTE COUNTY—Campbell, M. R.
Kent, B. H. (1969a)
________ (1969b)
Wolfson, D. E., and Ortuglio, Carmen
WASHINGTON COUNTY—Berryhill, H. L., Jr. (1964)
Clapp, F. G. (1907a)
Clapp, F. G. (1907b)

HUNTINGDON COUNTY

Gardner, J. H. (1913), *The Broadtop coal field of Huntingdon, Bedford, and Fulton Counties*, Pennsylvania Geological Survey, 3rd ser., Report 10, 81 p., illus., includes atlas.

See: BLAIR COUNTY—Butts, Charles

INDIANA COUNTY

Campbell, M. R. (1904), *Description of the Latrobe quadrangle [Indiana and Westmoreland Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 110, 15 p., illus., includes geologic maps, scale 1:62,500.

Crentz, W. L., Steele, Fern, and Bailey, A. L. (1951), *Preparation characteristics of coal occurring in Indiana County, Pa.*, U. S. Bureau of Mines Report of Investigations 4763, 33 p., illus.

Dowd, J. J., Turnbull, L. A., Toenges, A. L., and others (1950), *Estimate of known recoverable reserves of coking coal in Indiana County, Pa.*, U. S. Bureau of Mines Report of Investigations 4757, 22 p., illus.

Richardson, G. B. (1904), *Description of the Indiana quadrangle*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 102, 7 p., illus., includes geologic maps, scale 1:62,500.

Shaffner, M. R. (1946), *Geology and mineral resources of the Smicksburg quadrangle [Indiana, Jefferson, and Armstrong Counties]*, Pennsylvania Geological Survey, 4th ser., Atlas 55, 252 p., illus., includes geologic map, scale 1:62,500.

Stone, R. W. (1905a), *Description of the Elders Ridge quadrangle [Indiana and Armstrong Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 123, 10 p., illus., includes geologic map, scale 1:62,500.

________ (1905b), *Mineral resources of the Elders Ridge quadrangle [Indiana and Armstrong Counties], Pennsylvania*, U. S. Geological Survey Bulletin 256, 86 p., illus.

Wolfson, D. E., Birge, G. W., and Naugle, B. W. (1957), *Carbonizing properties of Indiana County, Pa., coals*, U. S. Bureau of Mines Report of Investigations 5314, 18 p.

See: CAMBRIA COUNTY—Campbell, M. R., and others
Phalen, W. C.
Shaffner, M. N.
CLEARFIELD COUNTY—Ashley, G. H. (1926)
SOMERSET COUNTY—Phalen, W. C.

JEFFERSON COUNTY

Crentz, W. L., and Miller, J. W. (1963), *Preparation characteristics of coal from Jefferson County, Pa.*, U. S. Bureau of Mines Report of Investigations 4941, 21 p., illus.

Dowd, J. J., Toenges, A. L., Abernethy, R. F., and Reynolds, D. A. (1952), *Estimate of known recoverable reserves of coking coal in Jefferson County, Pa.*, U. S. Bureau of Mines Report of Investigations 4840, 18 p., illus.

Graeber, C. K., and Foose, R. M. (1942), *Geology and mineral resources of the Brookville quadrangle [Jefferson, Clarion, and Armstrong Counties]*, Pennsylvania Geological Survey, 4th ser., Atlas 54, 136 p., illus., includes geologic map, scale 1:62,500.

See: CLEARFIELD COUNTY—Ashley, G. H. (1926)
Berg, T. M., and Glover, A. D.
Glover, A. D., and Bragonier, W. A.
ELK COUNTY—Birge, G. W., and others
INDIANA COUNTY—Shaffner, M. N.

LACKAWANNA COUNTY

Darton, N. H. (1940), *Some structural features of the Northern Anthracite coal basin, [northeastern] Pennsylvania*, U. S. Geological Survey Professional Paper 193-D, p. 69-81, illus.

Hill, F. A., Griffith, William, Quin, R. A., and others (1889a), *Atlas, Northern Anthracite field, Part III*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps and columnar sections.

________ (1889b), *Atlas, Northern Anthracite field, Part IV*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps.

________ (1889c), *Atlas, Northern Anthracite field, Part V*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes cross sections and columnar sections.

________ (1891), *Atlas, Northern Anthracite field, Part VI*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes cross sections.

Kehn, T. M., Glick, E. E., and Culbertson, W. C. (1966), *Geology of the Ransom quadrangle, Lackawanna, Luzerne, and Wyoming Counties, Pennsylvania*, U. S. Geological Survey Bulletin 1213, 81 p., illus., includes geologic map.

Sanner, W. S. (1967), *Preparation characteristics of Pennsylvania anthracite from the Bottom Red Ash bed, Northern field*, U. S. Bureau of Mines Report of Investigations 6989, 36 p., illus.

See: LUZERNE COUNTY—Hill, F. A., and others (1885)
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A. (1887)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1895)

LAWRENCE COUNTY

DeWolf, F. W. (1929), *New Castle quadrangle [Lawrence and Beaver Counties]—Geology and mineral resources*, Pennsylvania Geological Survey, 4th ser., Atlas 5, 238 p., illus., includes geologic maps, scale 1:62,500.

Van Lieu, J. A., and Patterson, E. D. (1964), *Coal resources of Lawrence County, Pennsylvania*, U. S. Geological Survey Bulletin 1143-B, p. B1-B33, illus., includes geologic maps.

See: BEAVER COUNTY—Richardson, G. B.
Zeilinger, J. E.

LEBANON COUNTY

See: DAUPHIN COUNTY—Trexler, J. P., and Wood, G. H., Jr.
Wood, G. H., Jr., and Trexler, J. P.
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A., and others (1887)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1891b)
________ (1895)
Smith, A. D. W., and others (1889b)
Wood, G. H., Jr. (1968)
Wood, G. H., Jr., and Kehn, T. M. (1968a)

LUZERNE COUNTY

Ash, S. H. (1950), *Buried valley of the Susquehanna River, anthracite region of Pennsylvania [Luzerne County]*, U. S. Bureau of Mines Bulletin 494, 27 p., illus.

Ashburner, C. A., Berlin, A. P., Winslow, Arthur, and others (1885), *Atlas, Eastern Middle Anthracite field, Part I*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps, cross sections, and columnar sections.

Ashburner, C. A., Hill, F. A., Parrish, H. E., and others (1885), *Atlas, Northern Anthracite field, Part I*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps, cross sections, and columnar sections.

Bergin, M. J. (1973), *Bedrock geologic map of the anthracite-bearing strata in the northwestern part of the Wilkes-Barre East quadrangle, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-753, scale 1:12,000.

________ (1976), *Bedrock geologic map of the anthracite-bearing rocks in the Wilkes-Barre West quadrangle, Luzerne County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-838, scale 1:12,000.

Hill, F. A., Ashburner, C. A., Griffith, William, and others (1885), *Atlas, Northern Anthracite field, Part II*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps and columnar sections.

Hill, F. A., Moister, I. R., Jones, Charles, and others (1888), *Atlas, Eastern Middle Anthracite field, Part II*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps and columnar sections.

Hill, F. A., Moister, I. R., Emory, G. W., and others (1889), *Eastern Anthracite field, Part III*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps, cross sections, and columnar sections.

See: CARBON COUNTY—Ash, S. H., and others
LACKAWANNA COUNTY—Darton, N. H.
Hill, F. A., and others (1889c)
________ (1891)
Kehn, T. M., and others
Sanner, W. S.
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A., and others (1887)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1895)

LYCOMING COUNTY

Sherwood, Andrew, and Platt, Franklin (1880), *The geology of Lycoming and Sullivan Counties*, Pennsylvania Geological Survey, 2nd ser., Report GG, 268 p., illus., includes geologic maps.

McKEAN COUNTY

Ashburner, C. A. (1880), *The geology of McKean County, and its connection with that of Cameron, Elk, and Forest [Counties]*, Pennsylvania Geological Survey, 2nd ser., Report R, 371 p., includes geologic maps.

MERCER COUNTY

White, I. C. (1880), *The geology of Mercer County*, Pennsylvania Geological Survey, 2nd ser., Report QQQ, 233 p., illus., includes geologic map.

NORTHUMBERLAND COUNTY

Arndt, H. H., Danilchik, Walter, and Wood, G. H., Jr. (1963), *Geology of anthracite in the western part of the Shamokin quadrangle, Northumberland County, Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-47, 2 sheets, scale 1:12,000, includes text.

Arndt, H. H., Wood, G. H., Jr., and Danilchik, Walter (1963), *Geology of anthracite in the southern part of the Trevorton quadrangle, Northumberland County, Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-48, 2 sheets, scale 1:12,000, includes text.

Arndt, H. H., Wood, G. H., Jr., and Schryver, R. F. (1973), *Geologic map of the south half of the Shamokin quadrangle, Northumberland and Columbia Counties, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-734, scale 1:24,000.

Danilchik, Walter, Arndt, H. H., and Wood, G. H., Jr. (1962), *Geology of anthracite in the eastern part of the Shamokin quadrangle, Northumberland County, Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-46, 2 sheets, scale 1:12,000, includes text.

Hill, F. A., Ashburner, C. A., Harden, O. B., and others (1887), *Atlas, Western Middle Anthracite field, Part II*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps.

Hill, F. A., Wells, Bard, Smith, A. D. W., and others (1891), *Atlas, Western Middle Anthracite field, Part III*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps and cross sections.

Rothrock, H. E., Wagner, H. C., and Haley, B. R. (1950), *Geology of anthracite in the west-central part of the Mount Carmel quadrangle [Northumberland County], Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-3, 3 sheets, scale 1:6,000, includes text and cross sections.

Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H. (1951), *Geology of anthracite in the southwestern part of the Mount Carmel quadrangle [Northumberland County], Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-7, 3 sheets, scale 1:6,000, includes sections and text.

Trexler, J. P., and Wood, G. H., Jr. (1968), *Geologic map of the Klingerstown quadrangle, Northumberland, Schuylkill, and Dauphin Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-700, scale 1:24,000.

See: COLUMBIA COUNTY—Arndt, H. H. (1971b)
Rothrock, H. E., and others (1951)
________ (1953)
SCHUYLKILL COUNTY—Trexler, J. P., and Wood, G. H., Jr.
Wood, G. H., Jr., and Trexler, J. P. (1968a)

POTTER COUNTY

Fuller, M. L., and Alden, W. C. (1903), *Description of the Gaines quadrangle [Potter and Tioga Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 92, 9 p., illus., includes geologic map, scale 1:62,500.

See: BRADFORD COUNTY—Platt, Franklin

SCHUYLKILL COUNTY

Ashburner, C. A. (1883), *First report of progress in the anthracite coal region—The geology of the Panther Creek basin or eastern end of the Southern field*, Pennsylvania Geological Survey, 2nd ser., Report AA, 407 p., illus.

________ (1885), *Second report of progress in the anthracite coal region—Part I. Statistics of production and shipment for 1883 and 1884*, Pennsylvania Geological Survey, 2nd ser., Report AA, 21 p.

________ (1886), *Second report of progress in the anthracite coal-regions—Part II*, in *Annual report of the Geological Survey of Pennsylvania for 1885*, Pennsylvania Geological Survey, 2nd ser., p. 268-490, illus.

Ashburner, C. A., Hill, F. A., Harden, O. B., and others (1887), *Atlas, Annual Report 1886, Part III*, Pennsylvania Geological Survey, 2nd ser., includes mine maps.

Ashburner, C. A., Sheafer, A. W., Hill, F. A., and others (1882), *Atlas, Southern Anthracite field, Part I*, Pennsylvania Geological Survey, 2nd ser., Report AA, includes geologic maps, mine maps, and cross sections.

Ashburner, C. A., Sheafer, A. W., Wells, Bard, and others (1884), *Atlas, Western Middle Anthracite field, Part I,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps and cross sections.

Danilchik, Walter, Rothrock, H. E., and Wagner, H. C. (1955), *Geology of anthracite in the western part of the Shenandoah quadrangle [Schuylkill County], Pennsylvania,* U. S. Geological Survey Coal Investigations Map C-21, 2 sheets, scale 1:12,000, includes sections and text.

Hill, F. A. (1887), *Annual report of the Geological Survey of Pennsylvania for 1886—Part III. Anthracite coal region,* Pennsylvania Geological Survey, 2nd ser., p. 919-1329, illus.

Hill, F. A., Smith, A. D. W., Kaercher, E. E., and others (1889a), *Atlas, Southern Anthracite field, Part II,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps.

________ (1889b), *Atlas, Southern Anthracite field, Part III,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes mine maps.

Hill, F. A., Smith, A. D. W., Quin, R. A., and others (1891), *Atlas, Southern Anthracite field, Part IV,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes columnar sections.

Kehn, T. M., and Wagner, H. C. (1955), *Geology of anthracite in the eastern part of the Shenandoah quadrangle [Schuylkill County], Pennsylvania,* U. S. Geological Survey Coal Investigations Map C-19, 2 sheets, scale 1:12,000, includes sections and text.

Lyman, B. S. (1889), *Report on the New Boston and Morea Coal Lands, in Schuylkill County, Pennsylvania; accompanied by a geological and topographical map,* in *Annual report of the Geological Survey of Pennsylvania for 1887,* Pennsylvania Geological Survey, 2nd ser., p. 37-91.

Maxwell, J. A., and Rothrock, H. E. (1955), *Geology of anthracite in the western part of the Delano quadrangle [Schuylkill County], Pennsylvania,* U. S. Geological Survey Coal Investigations Map C-25, 2 sheets, scale 1:12,000, includes sections and text.

Platt, Franklin (1881), *A special report to the legislature upon the causes, kinds and amount of waste in mining anthracite,* Pennsylvania Geological Survey, 2nd ser., Report A2, 134 p., illus.

Smith, A. D. W. (1890), *New general map of the anthracite region,* Pennsylvania Geological Survey, 2nd ser.

________ (1891a), *Atlas, Southern Anthracite field, Part V,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes cross sections.

________ (1891b), *Atlas, Southern Anthracite field, Part VI,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes cross sections.

________ (1895), *Report on the anthracite region,* in Lesley, J. P., d'Invilliers, E. V., and Smith, A. D. W., *A summary description of the geology of Pennsylvania—Volume 3, Part I, Describing the Carboniferous Formation,* Pennsylvania Geological Survey, 2nd ser., Summary Final Report, p. 1916-2153, illus.

Smith, A. D. W., and Wright, C. J. (1891), *Atlas, Southern Anthracite field, Part IVB,* Pennsylvania Geological Survey, 2nd ser., Report AA, includes columnar sections.

Trexler, J. P., and Wood, G. H., Jr. (1968), *Geologic map of the Valley View quadrangle, Schuylkill and Northumberland Counties, Pennsylvania,* U. S. Geological Survey Geologic Quadrangle Map GQ-699, scale 1:24,000.

Wood, G. H., Jr. (1968), *Geologic map of the Tower City quadrangle, Schuylkill, Dauphin, and Lebanon Counties, Pennsylvania,* U. S. Geological Survey Geologic Quadrangle Map GQ-698, scale 1:24,000.

________ (1972a), *Geologic map of anthracite-bearing rocks in the northern part of the Orwigsburg quadrangle, Schuylkill County, Pennsylvania,* U. S. Geological Survey Miscellaneous Geologic Investigations Map I-689, scale 1:12,000.

________ (1972b), *Geologic map of anthracite-bearing rocks in the Pottsville quadrangle, Schuylkill County, Pennsylvania,* U. S. Geological Survey Miscellaneous Geologic Investigations Map I-681, scale 1:12,000.

Wood, G. H., Jr. (1973a), *Geologic map of the Orwigsburg quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1029, scale 1:24,000.

________ (1973b), *Geologic map of the Pottsville quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1028, scale 1:24,000.

________ (1974), *Geologic map of anthracite-bearing rocks in the southern half of the Delano quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-737, scale 1:12,000.

Wood, G. H., Jr., and Arndt, H. H. (1969), *Geologic map of the Shenandoah quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-781, scale 1:24,000.

________ (1973), *Geologic map of the Delano quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1054, scale 1:24,000.

Wood, G. H., Jr., and Kehn, T. M. (1968a), *Geologic map of the Pine Grove quadrangle, Schuylkill, Lebanon, and Berks Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-691, scale 1:24,000.

________ (1968b), *Geologic map of the Swatara Hill quadrangle, Berks and Schuylkill Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-689, scale 1:24,000.

Wood, G. H., Jr., and Trexler, J. P. (1968a), *Geologic map of the Tremont quadrangle, Schuylkill and Northumberland Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-692, scale 1:24,000.

________ (1968b), *Geologic maps of anthracite-bearing rocks in the west-central part of the Southern Anthracite field, Pennsylvania, western area*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-529, scale 1:12,000.

Wood, G. H., Jr., Trexler, J. P., and Arndt, H. H. (1962), *Pennsylvanian rocks of the southern part of the Anthracite region of eastern Pennsylvania*, in *Geological Survey research 1962*, U. S. Geological Survey Professional Paper 450-C, p. C39-C42, illus.

Wood, G. H., Jr., Trexler, J. P., and Kehn, T. M. (1969), *Geology of the west-central part of the Southern Anthracite field and adjoining areas, Pennsylvania*, U. S. Geological Survey Professional Paper 602, 143 p., illus.

Wood, G. H., Jr., Trexler, J. P., and Yelenosky, Andrew (1968), *Geologic map of the Minersville quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-690, scale 1:24,000.

Wood, G. H., Jr., Trexler, J. P., Yelenosky, Andrew, and Soren, Julian (1958), *Geology of the northern half of the Minersville quadrangle and a part of the northern half of the Tremont quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Coal Investigations Map C-43, 2 sheets, scale 1:12,000, includes cross sections and text.

________ (1962), *Geology of rocks of Pennsylvanian age in the southern half of the Tremont quadrangle, Schuylkill County, Pennsylvania*, U. S. Geological Survey Bulletin 1112-F, p. F181-F208, illus., includes geologic map.

See: CARBON COUNTY—Wood, G. H., Jr. (1974a)
________ (1974b)
________ (1974c)
COLUMBIA COUNTY—Arndt, H. H. (1971a)
________ (1971b)
Haley, B. R.
Haley, B. R., and others
Rothrock, H. E., and others (1953)
DAUPHIN COUNTY—Trexler, J. P., and Wood, G. H., Jr.
Wood, G. H., Jr., and Trexler, J. P.

See: LUZERNE COUNTY— Hill, F. A., and others (1888)
________ (1889)
NORTHUMBERLAND COUNTY—Hill, F. A., and others (1887)
________ (1891)
Trexler, J. P., and Wood, G. H., Jr.

SOMERSET COUNTY

Crentz, W. L., Bailey, A. L., and Miller, J. W. (1951), *Preparation characteristics of coal from Somerset County, Pa.*, U. S. Bureau of Mines Report of Investigations 4834, 23 p., illus.

Flint, N. K. (1956), *Preliminary report, geology and mineral resources of southern Somerset County*, Pennsylvania Geological Survey, 4th ser., Progress Report 149, geologic map and text.

________ (1965), *Geology and mineral resources of southern Somerset County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., County Report 56A, 267 p., illus., includes geologic map, scale 1:62,500.

Harden, E. B. (1886), *Report on fire-clay*, in *Annual report of the Geological Survey of Pennsylvania for 1885*, Pennsylvania Geological Survey, 2nd ser., p. 239-249.

Lesley, J. P. (1886), *The coal-beds and fireclays of the Wellersburg basin in Somerset County*, in *Annual report of the Geological Survey of Pennsylvania for 1885*, Pennsylvania Geological Survey, 2nd ser., p. 227-239.

Phalen, W. C. (1910), *Description of the Johnstown quadrangle [Somerset, Westmoreland, Indiana, and Cambria Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 174, 15 p., illus., includes geologic maps, scale 1:62,500.

Richardson, G. B. (1934), *Description of the Somerset and Windber quadrangles [Somerset, Bedford, Westmoreland, and Cambria Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 224, 14 p., illus., includes geologic maps, scale 1:62,500.

Wallace, J. J., Dowd, J. J., Bowsher, J. A., and others (1953), *Estimate of known recoverable reserves of coking coal in Somerset County, Pa.*, U. S. Bureau of Mines Report of Investigations 4998, 20 p., illus.

Wolfson, D. E., Birge, G. W., and Naugle, B. W. (1956), *Carbonizing properties of Somerset County, Pa., coals*, U. S. Bureau of Mines Report of Investigations 5269, 19 p.

See: CAMBRIA COUNTY—Phalen, W. C.
Shaffner, M. N.
FAYETTE COUNTY—Martin, G. C.
Shaffner, M. N.

SULLIVAN COUNTY

See: LYCOMING COUNTY—Sherwood, Andrew, and Platt, Franklin
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A., and others (1887)
Hill, F. A.
Platt, Franklin
Smith, A. D. W. (1890)
________ (1895)

SUSQUEHANNA COUNTY

White, I. C. (1881), *The geology of Susquehanna County and Wayne County*, Pennsylvania Geological Survey, 2nd ser., Report G5, 243 p., illus., includes geologic map.

See: LACKAWANNA COUNTY—Hill, F. A., and others (1889b)
________ (1889c)
________ (1891)

TIOGA COUNTY

See: BRADFORD COUNTY—Platt, Franklin
POTTER COUNTY—Fuller, M. L., and Alden, W. C.

VENANGO COUNTY

See: CLARION COUNTY—Shaw, E. W., and others

WASHINGTON COUNTY

Berryhill, H. L., Jr. (1964), *Geology of the Amity quadrangle [Washington and Greene Counties], Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-296, scale 1:24,000, includes text.

Berryhill, H. L., Jr., and Schweinfurth, S. P. (1964), *Geology of the Ellsworth quadrangle [Washington County], Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-333, scale 1:24,000, includes text.

Berryhill, H. L., Jr., Schweinfurth, S. P., and Kent, B. H. (1971), *Coal-bearing Upper Pennsylvanian and Lower Permian rocks, Washington area, Pennsylvania, Part 1. Lithofacies; Part 2. Economic and engineering geology*, U. S. Geological Survey Professional Paper 621, 47 p.

Berryhill, H. L., Jr., and Swanson, V. E. (1962), *Revised stratigraphic nomenclature for Upper Pennsylvanian and Lower Permian rocks, Washington County, Pennsylvania*, in *Geological Survey research 1962*, U. S. Geological Survey Professional Paper 450-C, p. C43-C46, illus.

________ (1964), *Geology of the Washington West quadrangle [Washington County], Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-283, scale 1:24,000, includes text.

Clapp, F. G. (1907a), *Description of the Amity quadrangle [Washington and Greene Counties]*, U. S. Geological Survey Geologic Atlas of the U. S., Folio 144, 15 p., illus., includes geologic maps, scale 1:62,500.

________ (1907b), *Economic geology of the Amity quadrangle, eastern Washington County, Pennsylvania*, U. S. Geological Survey Bulletin 300, 145 p., illus.

Gray, T. E., and Palowitch, E. R. (1960), *Preparation characteristics of coal from Washington County, Pa.*, U. S. Bureau of Mines Report of Investigations 5475, 27 p., illus.

Kent, B. H. (1963), *Geologic map of the Hackett quadrangle, Washington County, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-630, scale 1:24,000, includes text.

________ (1972), *Geologic map of the Prosperity quadrangle [Washington County], southwestern Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1003, scale 1:24,000.

Kim, A. G. (1974), *Methane in the Pittsburgh coalbed, Washington County, Pa.*, U. S. Bureau of Mines Report of Investigations 7969, 16 p., illus.

Roen, J. B. (1973), *Geologic map of the Midway quadrangle, Washington County, southwestern Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-1067, scale 1:24,000.

Schweinfurth, S. P. (1967a), *Geologic map of the California quadrangle, Washington and Fayette Counties, Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-648, scale 1:24,000, includes text.

Schweinfurth, S. P. (1967b), *Geologic map of the West Middletown quadrangle, and part of the Bethany quadrangle, Washington County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-871, scale 1:24,000.

——— (1976), *Geologic map of the Avella quadrangle and part of the Steubenville East quadrangle, Washington County, Pennsylvania*, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-908, scale 1:24,000.

Swanson, V. E., and Berryhill, H. L., Jr. (1964), *Geology of the Washington East quadrangle [Washington County], Pennsylvania*, U. S. Geological Survey Geologic Quadrangle Map GQ-334, scale 1:24,000.

Wallace, J. J., Dowd, J. J., Provost, J. M., and others (1955), *Estimate of known recoverable reserves of coking coal in Washington County, Pa.*, U. S. Bureau of Mines Report of Investigations 5109, 23 p., illus.

See: ALLEGHENY COUNTY—Bushnell, K. O.
Bushnell, K. O., and Peak, J. R.
Campbell, M. R.
Johnson, M. E.
Roen, J. B., and others
Shaw, E. W., and Munn, M. J.
FAYETTE COUNTY—Campbell, M. R.
Kent, B. H. (1969a)
——— (1969b)
Wolfson, D. E., and Ortuglio, Carmen
GREENE COUNTY—Clapp, F. G.
Munn, M. J.
Stone, R. W. (1905)

WAYNE COUNTY

See: LACKAWANNA COUNTY—Hill, F. A., and others (1889b)
——— (1889c)
——— (1891)
SUSQUEHANNA COUNTY—White, I. C. (1881)

WESTMORELAND COUNTY

Birge, G. W., and Wolfson, D. E. (1957), *Carbonizing properties of Westmoreland County, Pa., coals*, U. S. Bureau of Mines Report of Investigations 5374, 12 p., illus.

Crentz, W. L., Bailey, A. L., and Miller, J. W. (1951), *Preparation characteristics of coal occurring in Westmoreland County, Pa.*, U. S. Bureau of Mines Report of Investigations 4823, 17 p., illus.

Dowd, J. J., Turnbull, L. A., Toenges, A. L., and others (1951), *Estimate of known recoverable reserves of coking coal in Westmoreland County, Pa.*, U. S. Bureau of Mines Report of Investigations 4803, 16 p., illus.

Johnson, M. E. (1925), *Mineral resources of the Greensburg quadrangle [Westmoreland County], Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 37, 162 p., illus., includes geologic map, scale 1:62,500.

Sholes, M. A., Skema, V. W., and Edmunds, W. E. (1979), *The economic geology of the Upper Freeport coal in the New Stanton area of Westmoreland County, Pennsylvania: A model for coal exploration*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 75, 51 p., illus.

See: ALLEGHENY COUNTY— Bushnell, K. O.
Bushnell, K. O., and Peak, J. R.
Campbell, M. R.

See: ALLEGHENY COUNTY— Cortis, S. E., and others
Craft, J. L., and others
Hughes, H. H.
Johnson, M. E.
Koppe, E. F.
Richardson, G. B.
Roen, J. B., and others
Wagner, W. R., and others
CAMBRIA COUNTY—Phalen, W. C.
Shaffner, M. N.
FAYETTE COUNTY—Shaffner, M. N.
INDIANA COUNTY—Campbell, M. R.
SOMERSET COUNTY—Phalen, W. C.
Richardson, G. B.

WYOMING COUNTY

See: LACKAWANNA COUNTY—Kehn, T. M., and others
SCHUYLKILL COUNTY—Ashburner, C. A. (1885)
________ (1886)
Ashburner, C. A., and others (1887)
Smith, A. D. W. (1890)
________ (1895)